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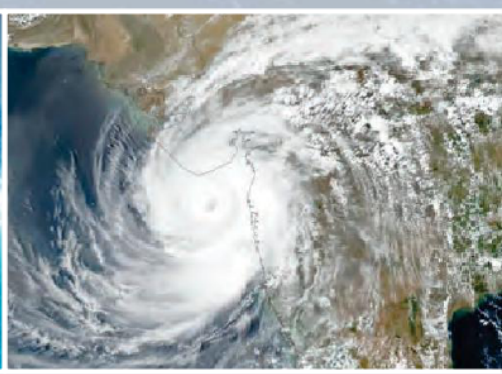
STANDARD OPERATING PROCEDURE (SOPs) FOR CYCLONE AND TSUNAMI FOR ACTION IN MARITIME DOMAIN





DIRECTORATE OF OPERATIONS & COASTAL SECURITY
COAST GUARD HEADQUARTERS, NEW DELHI

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(a) National Disaster Management Guidelines, w.r.t Management of Cyclones published by NDMA/GoI in Apr 2008.

(b) Cyclone Warning in India, Standard Operating Procedure published by IMD/MoES/GoI in Mar 2021.

(c) Memorandum of Understanding among DGH, OSID, IMD, INCOIS, dated 22 Mar 2022.

(d) National Disaster Management Guidelines w.r.t Management of Tsunamis published by NDMA/GoI in 22 Jul 2010.

(e) Directorate General of Shipping SOP's for Cyclones-2021

(f) 'SOP Training Manual' (Indian Tsunami Early Warning Centre) published by Indian National Centre for Ocean Information Services (INCOIS).

(g) Petroleum and Natural Gas (Safety in Offshore Operations) Rules, 2008.

DISCLAIMER

THIS DOCUMENT PROVIDES BASIC FRAMEWORK FOR CYCLONE AND TSUNAMI RESPONSE SOP IN MARITIME DOMAIN. RESPECTIVE ORGANISATIONS/ STAKE HOLDERS ARE TO PREPARE CUSTOMISED INTERNAL SOPs, BASED ON THIS FRAME WORK AND MHA SOPs ON SUBJECT.

IN CASE OF ANY INCONSISTENCY IN PROVISION OF THIS SOP WITH THE STATUTORY PROVISIONS AND THE DIRECTIONS ISSUED BY THE ADMINISTRATIVE MINISTRY, THE STATUTORY PROVISIONS AND ADMINISTRATIVE DIRECTIONS OF THE MINISTRY WILL PREVAIL.

Preface

1. The Indian peninsula has been subjected to the vagaries of various natural calamities occurring with considerable frequency. It encompasses 13 Coastal States / UTs with a vast coastline spanning 11,098.81 km. Approximately eight per cent of the country's area and about one-third of its population reside in these coastal regions. India lies within the cyclone- prone belt, with the East coast being more susceptible to cyclone hazards than the West coast. Furthermore, the 2004 Tsunami in the Indian Ocean region underscored the importance of a coordinated response among various stakeholder.

2. Cyclones, monsoon conditions, and local weather phenomena are often accompanied by strong winds, rough seas, and heavy rainfall, posing significant risks to coastal areas and mariners' lives. Consequently, the Ministry of Home Affairs (MHA) has been designated as the nodal agency for mitigating cyclone and tsunami disaster risks and managing their impact. Standard Operating Procedures (SOPs) for this purpose have also been issued by the MHA.

3. This document outlines a Framework for the **'Standard Operating Procedure for Cyclone and Tsunami Risk Mitigation in the Maritime Domain**.' All stakeholders are required to develop their own agency-specific / internal SOPs based on the guidelines provided by the MHA on this subject. It is essential to note that proactive preventive measures by all stakeholders are crucial for effective cyclone / tsunami response and management. This Framework of SOPs advocates for a participatory approach involving all agencies, planners, and implementers to ensure effective risk mitigation.

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INDEX

SL	CHAPTER	PAGE NO.
	SECTION : I **SOP FOR CYCLONE RESPONSE IN MARITIME DOMAIN**	
1.	Introduction	**1-6**
2.	Stakeholders	**7-13**
3.	Early Warning Mechanism	**14-24**
4.	Preparedness and Response	**25-34**
	SECTION : II **SOP FOR TSUNAMI RESPONSE IN MARITIME DOMAIN**	
5.	Introduction	**35-36**
6.	Tsunami Risk Assessment and Vulnerability	**37-46**
7.	Emergency Tsunami Response	**47-49**
	Appendix	
8.	Appendix 'A'	**50**
9.	Appendix 'B'	**51**
10.	Appendix 'C'	**52-59**

RECORD OF AMENDMENTS

Sl.	Date	Amendment

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Sl.	Date	Amendment

ABBREVIATIONS

ACWC	Area Cyclone Warning Centre
AIR	All India Radio
ARB	Arabian Sea
BOB	Bay of Bengal
CWC	Cyclone Warning Centre
CISF	Central Industrial Security Force
CDO	Central Dense Overcast
CSP	Coastal Security Police
CWD	Cyclone Warning Division
DDMA	District Disaster Management Authority
DGLL	Directorate General of Lighthouse and Lightships
DGH	Directorate General of Hydrocarbon
ECMWF	European Centre for Medium Range Weather Forecasting
ERP	Emergency Response Plan
ETV	Emergency Towing Vessel
GMDSS	Global Maritime Distress and Safety System
IAF	Indian Air Force
ICG	Indian Coast Guard
INCOIS	Indian National Centre for Ocean Information Services
IGCG	Inter-Governmental Coordination Group
INOSHAC	Indian Ocean & South Hemispheric Centre
IOTWMS	Indian Ocean Tsunami Warning & Mitigation System
ISRO	Indian Space Research Organisation
ITEWC	Indian Tsunami Early Warning Centre
IMD	Indian Meteorological Department

IN	Indian Navy
INMARSAT	International Maritime Satellite Organisation
JTWC	Joint Typhoon Warning Centre
LES	Land Earth Station
MSD	Marine Services Division
NCC	National Cadet Corps
NSS	National Service Scheme
NDRF	National Disaster Response Force
NBDP	Narrow Band Direct Printing
NIO	North Indian Ocean
NHAC	Northern Hemisphere Analysis Centre
NCMRWF	National Centre for Medium Range Weather Forecasting
NRSA	National Remote Sensing Agency
NGO	Non-Governmental Organisation
NIO	North Indian Ocean
NHO	National Hydrographic Office
NDMA	National Disaster Management Authority
ODA	Offshore Development Area
ODAG	Offshore Defence Advisory Group
OHA	Oil Handling Agencies
ONGC	Oil and Natural Gas Corporation
OISD	Oil Industry Safety Directorate
P&NG	Petroleum & Natural Gas
PUCs,	Public Undertaking Company
RSMC	Regional Specialised Meteorological Centre
RTH	Regional Telecommunication Hub
SDRF	State Disaster Response Force

SDMA	State Disaster Management Authority
SPOC	Single Point of Contact
TC	Tropical Cyclone
TSP	Tsunami Service Provider
UKMO	United Kingdom Meteorological Office
WMO	World Meteorological Organisation
Web-DCRA	Web-based Dynamic Composite Risk Atlas & Decision Support System

SECTION : I

SOP FOR CYCLONE RESPONSE IN MARITIME DOMAIN

CHAPTER-1

INTRODUCTION

CHAPTER-1

INTRODUCTION

1. **Overview**. Tropical Cyclone (TC), commonly referred to as a 'Cyclone', is a term used globally to describe tropical weather systems characterised by winds equal to or exceeding 'gale force,' which is 34 knots (62 km/h). These are highly intense low-pressure systems within the Earth's atmosphere and are extreme weather events typically found in tropical regions. In meteorology, winds rotate around the low-pressure centre in an anti-clockwise direction in the Northern Hemisphere and clockwise direction in the Southern Hemisphere. The term 'Cyclone' originates from the Greek word 'Cyclos,' meaning the coil of a snake.

2. Tropical Cyclones mostly originate on the eastern side of the North Indian Ocean (NIO) basin and initially move in a west-northwest/northwest direction. The Bay of Bengal sees a higher number of cyclones compared to the Arabian Sea. The frequency of cyclones in the NIO Basin follows a bimodal pattern, which is unique to this region. Cyclones are most prevalent during the months of April to June and October to December, with the primary peak occurring in November and a secondary peak in May.

3. Cyclones are characterized by **destructive winds, storm surges, and heavy rainfall**. Cyclones in the Bay of Bengal, striking the East coast of India and Bangladesh, typically produce higher storm surges compared to other parts of the world due to the unique nature of the coastline, shallow coastal bathymetry, and tidal characteristics. The coastal impact is significant because of the low-lying flat coastal terrain, high population density, limited community awareness, insufficient response and preparedness, and the absence of adequate mitigation measures.

4. **Cyclogenesis**. Cyclones are atmospheric and oceanic phenomena centred on areas of low atmospheric pressure, typically forming over warm ocean waters near the equator. As warm, moist air rises from the ocean surface, it creates a low- pressure zone at the surface. The following conditions have emerged from observations and scientific studies: -

(a) A warm sea surface (temperature above 26.5°C) accompanied by warming extending to a depth of 60 meters, with abundant water vapour in the overlying air.

(b) High relative humidity in the atmosphere up to an altitude of approximately 5,000 meters.

(c) Atmospheric instability that promotes the formation of large vertical cumulus clouds due to the condensation of rising moist air.

(d) Low vertical wind shear between lower and higher levels of the atmosphere, preventing the transport of heat generated and released by the clouds from the area.

(e) The presence of cyclonic vortices (anticlockwise rotation of air) that initiate and support the cyclonic rotation of air masses.

(f) Location over the ocean, at least 5°N latitude away from the equator.

5. **Classification of Cyclonic Disturbances**. Cyclones are intense low-pressure areas, characterized by a decrease in pressure towards the centre. The magnitude of the pressure drop at the centre and the rate at which it increases outward determine the intensity of cyclones and the strength of winds they produce. The Indian Meteorological Department (IMD) classifies cyclones in the Bay of Bengal and the Arabian Sea according to the standards adopted by the World Meteorological Organization (WMO), as follows:-

Sl.	Type of Disturbance	Maximum Sustained Wind.
(a)	Low pressure Area	Not exceeding 17 knots (<31 kmph)
(b)	Depression	17 to 27 knots (31-49 kmph)
(c)	Deep Depression	28 to 33 knots (50-61 kmph)
(d)	Cyclonic Storm	34 to 47 knots (62-88 kmph)
(e)	Severe Cyclonic Storm	48 to 63 knots (89-117 kmph)
(f)	Very Severe Cyclonic Storm	64 to 89 knots (119-165 kmph)
(g)	Extremely Severe Cyclonic Storm	90 to 119 knots (167-220 kmph)
(h)	Super Cyclonic Storm	120 knots and above(≥ 222 kmph)

Source: Table 1.1, Chapter-1 of Cyclone Warning in India, Standard Operating Procedure published by IMD/MoES/GoI in Mar 2024.

6. **Structure of Tropical Cyclone.** Tropical cyclones are warm-core low-pressure systems characterised by a large vortex in the atmosphere, sustained by the release of latent heat from convective clouds forming over warm oceans. In the Northern Hemisphere, cyclonic winds circulate counter clockwise in the lower troposphere and clockwise in the upper troposphere. Conversely, in the Southern Hemisphere, cyclonic winds circulate clockwise in the lower levels and counter clockwise in the upper levels.

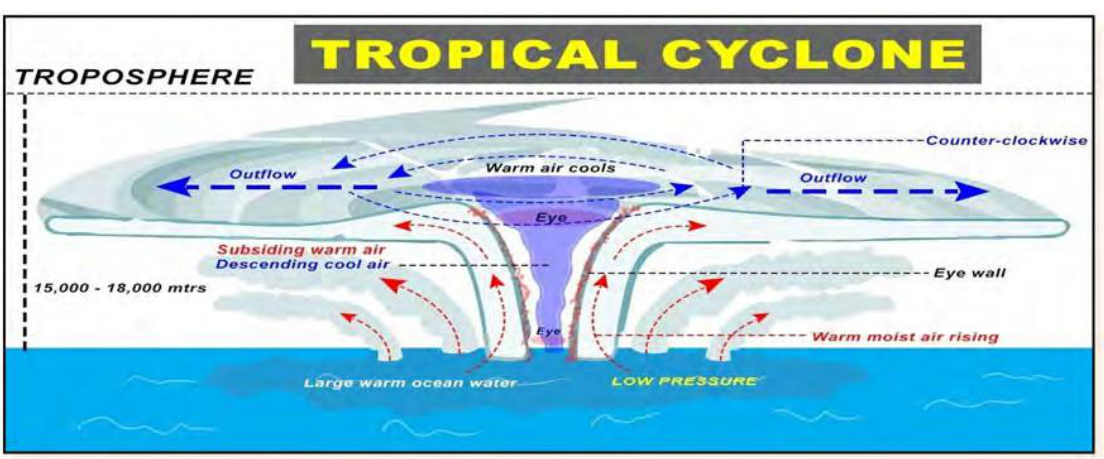
7. **Major Components of Tropical Storm**:-

(a) **Eye**. A defining feature of a mature cyclonic storm is its eye, described as the most spectacular part. The eye forms at the centre of the storm within a Central Dense Overcast (CDO) region. With a diameter typically ranging from 10 to 100 km with an average of 50 km, the eye is generally cloud-free and is encircled by thick wall clouds. Its appearance resembles an 'eye' when observed in satellite and radar imagery. The eye is a calm region characterized by minimal rainfall and no wind.

(b) **Wall Cloud Region or Eye Wall**. The eye is surrounded by a 10-15 km thick wall of convective clouds where the maximum winds occur, making it the most dangerous part of a cyclonic storm. The height of the wall extends up to 10 to 15 km. The intense convection in this wall cloud region produces torrential rain.

(c) **Rain/Spiral Bands**. Beyond the eye wall region, the major convective clouds in a cyclonic storm, responsible for heavy rains, exhibit a spirally banded structure. These spiral bands can extend for hundreds of kilometres and are typically a few kilometres wide.

(d) **Outer Storm Area**. This region extends beyond 250 kilometres from the centre, where the winds are cyclonic but gradually decrease in speed as one moves outward. The weather conditions in the outer storm area are comparatively better and are, characterized by scattered cumulus clouds interspersed with spiral bands.



8. **Life Cycle of Cyclone**

(a) **Formative Stage**. This stage spans from the genesis of a cyclonic circulation to the formation of cyclonic storm stage, passing through the phases of low pressure, depression, and deep depression.

(b) **Immature Stage**. During this stage, the central pressure of the system continues to decrease until the lowest pressure is reached. Wind speeds escalate reaching it's peak, and typically, a well-developed eye wall is observed at a distance of about 30-50 km from the centre. No further intensification occurs beyond this stage. This stage can persist for up to three days.

(c) **Mature Stage**. In the mature stage, there is no further drop in pressure, and the wind speeds stabilize. In some instances, winds from very severe cyclonic storms can extend several hundreds of kilometres from the storm centre, primarily to the right of the storm's motion in the Northern Hemisphere.

(d) **Decaying Stage**. During the decaying stage, tropical storms begin to lose their intensity. This can occur when they move over land or over an area with unfavourable environmental conditions like, colder water, or encounter an unfavourable large-scale flow aloft. In some cases, they may be influenced by an upper air trough and recurve towards the northeast. Storms weaken over land due to a sharp reduction in moisture supply and increased surface friction.

9. **Marine Impact of Cyclonic Storm**.

(a) A Tropical Cyclone is a rapidly rotating storm system characterized by a low-pressure centre, a closed low-level atmospheric circulation, strong winds, and a spiral arrangement of thunderstorms that produce heavy seas, rains, and squalls. These conditions may result in the capsizing of fishing boats, damage to offshore structures, anchor breaking, oil spills, damage to ships berthed in harbours, and various hazards to marine shipping.

(b) **Marine Impact.**

Sl.	Intensity	Strength of Wind (kmph/ Knots)	Condition of sea	Wave height (in mtrs)	Action Suggested
(i)	Depression	(i) (31-40)/ kmph (17-21) Knots (ii)(41-49)/kmph (22-27) Knots	Moderate Rough	(i) 1.25-2.5 (ii) 2.5-4.0	**Initiate preventive actions** **Fishermen are advised not to venture into sea.** **Fishermen out at sea are advised to return to the coast.**
(ii)	Deep Depression	(50-61) kmph (28-33) Knots	Very Rough	4.0-6.0	(aa) **Fishermen advised not to venture into the**

					open sea. (ab) **Merchant Shipping/ Offshore platforms to be alerted**
(iii)	Cyclonic Storm	(62-87) kmph (34-47) Knots	High	6.0-9.0	(aa) **Total suspension of fishing operation.** (ab) **Safe evacuation from Offshore platforms, as required**
(iv)	Severe Cyclonic Storm	(88-117) kmph (48-63) Knots	Very High	9.0-14.0	
(v)	Very Severe Cyclonic Storm	(118-167) kmph (64-90) Knots	Phenomenal	Over 14.0	
(vi)	Extremely Severe Cyclonic storm	(168-221) kmph (91-119) Knots	Phenomenal	Over 14.0	
(vii)	Super Cyclonic Storm	≥222/≥120 kmph	Phenomenal	Over 14.0	

Note - Oil & Gas (E&P), Marine, Shipping Companies, and other marine spread to take evacuation call based on IMD advisory as per their ERP.

Sources - Table 1.3 , Chapter-1 of Cyclone Warning in India, Standard Operating Procedure published by IMD/MoES/GoI in Mar 2024.

CHAPTER-2

STAKEHOLDERS

CHAPTER – 2

STAKEHOLDERS

1. There are several agencies/parties that play major roles in the disaster management process. These include State / Central agencies, Communities, Regional institutions, NGOs, PUCs (Public Utility Companies), Media, and Scientific Communities. The principal categories of stakeholders are as follows: -

(a) **Communities**. The specific communities that are most vulnerable are key stakeholders in disaster management. They are crucial to people- centred early warning systems. Their input into system design and their ability to respond ultimately determine the extent of risk associated with natural hazards. The following key issues in the context of communities are as follows:

(i) The vulnerable communities need to be aware of hazards and potential negative impacts to which they are exposed, and be able to take specific actions to minimize the threat of loss or damage.

(ii) The most essential determinant of the selection of disasters on which the system should focus is the geographical location of such communities

(iii) Coastal communities need to be educated and prepared for the possibility of disasters.

(b) **Central Government**. The Central Government is responsible for policies and frameworks that facilitate early warning. It is also responsible for the technical systems necessary for the preparation and issuance of timely and effective hazard warnings for the entire country. The key issues for the Government are as follows: -

(i) The central government ensures that warnings and related responses are directed towards the most vulnerable populations through the design of holistic disaster response and early warning frameworks that address the specific needs of related micro and macro-level actions.

(ii) The provision of support to local communities and state governments to develop operational capabilities is an essential function to translate early warning knowledge into risk reduction practices. The following main bodies are key stakeholders (contact details are provided in **Appendix 'A'**) : -

(aa) Ministry of Home Affairs - MHA
(ab) Ministry of Shipping - MoS
(ac) Ministry of Petroleum 'and Natural Gas – MoPNG
(ad) Ministry of Earth Science – MoES
(ae) Port Authority
(af) India Meteorological Department - IMD
(ag) DG Shipping
(ah) Indian Coast Guard - ICG
(aj) Indian Navy - *IN*
(ak) Coastal Security Police – CSP
(al) Ministry of Fisheries, Animal Husbandry & Dairying (MoFAHD)
(am) Indian Customs
(an) State Administration
(ap) Indian National Centre for Ocean Information Services-INCOIS
(aq) Directorate General of Hydrocarbon - DGH
(ar) NDMA
(as) SDMA
(au) Oil & Gas (E&P) Companies such as ONGC etc.
(av) Oil Industry Safety Directorate (OISD)
(aw) Any other relevant agency which has requisite resources for disaster response.

(Note: Other agencies as deemed fit by response coordinator can be added)

(c) **Regional Institutions and Organisations**. These institutions provide specialized knowledge and advice to support national efforts in developing or sustaining the operational capabilities of countries that share a common geographical environment.

(d) **Non-Governmental Organisations (NGOs)**. NGOs play a critical role in raising awareness among individuals and organizations involved in early warning and in the implementation of early warning systems, particularly at the community level. Additionally, they advocate to ensure that early warning remains a priority on government policymakers' agendas.

(e) **The Private Sector**. The private sector have a diverse role in early warning, including developing early warning capabilities within their own organizations. They are also crucial for implementing ICT-based solutions. The private sector possesses untapped potential to provide skilled services such as technical manpower, know-how, or donations of goods or services,

especially for communication, dissemination, and response elements of early warning.

(f) **Media Group**. The media plays a crucial role in enhancing disaster awareness among the general population and disseminating early warnings. They serve as a critical link between the agencies providing warnings and the general public.

(g) **The Scientific Community**. Scientific organizations have a critical role in providing specialized scientific and technical input to assist governments in developing early warning systems. Their expertise is vital for analysing the risks communities face from natural hazards, supporting the design of scientific and systematic monitoring and warning services, fostering data exchange, and translating scientific or technical information.

2. **Responsibility of Agencies**. The management and response to cyclones entail multi-stakeholder operations and require the rapid dissemination of information and prompt on-scene action. Information dissemination and the initiation of response actions are time-sensitive activities that necessitate proper coordination and interaction among agencies. Further details regarding responsibilities in cyclone response in the maritime domain are outlined in subsequent paragraphs.

3. **India Meteorological Department (IMD)**. The India Meteorological Department (IMD) is tasked with disseminating cyclone warnings according to the existing cyclone warning structure. The Cyclone Warning Division (CWD) in the Office of Director General of Meteorology at New Delhi and the 3 Area Cyclone Warning Centre (ACWCs) & 4 Cyclone Warning Centres (CWCs) are responsible for disseminating warnings at National level and within their respective Areas of Responsibility (AoR) concerning sea areas, coastal areas, ~~and~~ & maritime States/UTs respectively. Cyclone track forecasts and all other forms of information dissemination shall adhere to the standard operating procedures (SOP) promulgated by the Ministry of Home Affairs (MHA) in 2021. Additionally, the ACWC shall issue cyclone warnings for ships on the high seas through the transmission of Global Maritime Distress and Safety System (GMDSS) bulletins and broadcasts. Both ACWC and CWC issue warnings to ships in high seas, ships in coastal waters, ports, fishermen, government officials, and the general public regarding adverse weather conditions.

4. **Indian Coast Guard (ICG)**. The Indian Coast Guard (ICG) shall initiate preventive actions in accordance with Chapter 4 of this document. As the national Maritime Search and Rescue Coordinator in the Indian Search and Rescue Region (ISRR), the ICG shall coordinate Search and Rescue (SAR) operations through the Maritime Rescue Coordination Centre (MRCC) in ISRR. All stakeholders are expected to provide necessary support during SAR operations. MRCC shall disseminate relevant safety information through available resources.

5. **Department of Fisheries**. The Department of Fisheries is responsible for ensuring that cyclone information is disseminated to fishers at sea as well as in all fishing villages. Proper accountability is to be maintained regarding fishermen venturing out at sea and returning. Additional community interaction programs, group messaging, notices, circulars, utilization of radio/print media, etc., are to be planned at short notice. Dept of Fisheries to oversee entry/exit of fishing boats from FLCs/FLPs/FHs and state Govts./UT Administration to provide necessary support for undertaking the same.

6. **Indian Space Research Organisation (ISRO)**. ISRO is setting up a National MSS network for Vessel Communication Support System towards monitoring, control and surveillance application in maritime domain for department of Fisheries and other special user groups. The network will support over one lakh mechanised and motorised fishing boats across nine coastal states and four UTs. Distress Alert Terminal – 2nd Generation (DAT-SG) supports reception of broadcast messages, directly from satellite, like Potential Fishing Zone advisories, Cyclone Warning etc. using a mobile application working on Android based smart phones. The DAT-SG terminals installed in the fishing boats will transmit distress alert messages after activation during an emergency. The messages contain terminal identification number, current location of the boat and type of alert. The Mission control centre located at Bangalore will receive and process the alert and transmit to the Maritime Research Co-ordination centre, Indian Coast Guard, Chennai.

7. **Port Authorities**. Port authorities are tasked with disseminating information to ships at harbours, anchorages, and alerting port officials. Regular broadcasts shall be made via Very High Frequency Radio Telephone (VHF RT) regarding cyclone warnings. Requisite actions are also to be initiated concerning advising ships in harbour/anchorage to shift to safer locations. Sea-going assets of ports, along with their crew, should be kept on standby for Search and Rescue (SAR) requirements.

8. **Indian Navy (*IN*)**. Indian Naval ships/aircraft are tasked with aiding in the dissemination of cyclone information to fishing boats/vessels at sea. Additionally, the Indian Navy shall support SAR operations when requested by maritime stakeholders such as the ICG, DGS, DGH, ONGC, etc. The operational control of units involved in SAR shall remain with the parent service. INHD shall promulgate warnings/forecasts according to their existing SOPs. SAR information sharing with MRCC as required.

9. **Indian Air Force (IAF)**. Details of assets capable of undertaking maritime search and rescue operations shall be communicated to MRCCs for SAR coordination in the ISRR.

10. **Coastal Security Police (CSP)**. The Coastal Security Police (CSP) is responsible for ensuring that cyclone early warning information is disseminated in all coastal villages. All CSP sea-going assets are to be kept on standby for short notice close coast SAR efforts. Additionally, necessary assistance is to be provided to the

Department of Fisheries (DoF) for monitoring Fishing Landing Points (FLPs)/Fishing Landing Centres (FLCs) and coordinating local-level SAR.

11. **Indian Customs**. Indian Customs are to assist port authorities in cyclone response preparedness. All sea-going assets of Indian Customs shall be on standby for any close coast SAR operations.

12. **Directorate General of Lighthouses and Lightships (DGLL)**. The DGLL is responsible for ensuring the operational state of aids to marine navigation as per the DGLL charter, which includes upkeep of Differential Global Positioning System (DGPS) stations, Nationwide Automatic Identification System (NAIS) network, Navigational Telex (NAVTEX), and other Aids to Navigation.

13. **Oil & Gas (E&P) Companies**. Ensure safety in Offshore Development Areas (ODA) and initiate preventive actions regarding evacuation and continuous weather monitoring as per their Emergency Response Plan (ERP). All sea-going assets shall be kept on standby for emergent Search and Rescue (SAR) requirements in ODA. Furthermore, details of sea-going assets/operations should also be communicated to the Maritime Rescue Coordination Centre (MRCC) on a real-time basis. All actions are to be overseen by DGH/OISD, as applicable.

14. **Indian National Center for Ocean Information Services** (**INCOIS**) is an autonomous organization of GoI, under MoES located at Hyderabad. INCOIS was established in 1998 under the Ministry of Earth Sciences (MoES) and is a unit of the Earth System Science Organization (ESSO). ESSO - INCOIS is mandated to provide the best possible ocean information and advisory services. INCOIS has set up 'Indian Tsunami Early Warning System' (ITEWS) for issuing Tsunami warnings. INCOIS has promulgated SOPs for ITEWS encompassing procedures to be adopted for Tsunami warning information dissemination.

15. **National Disaster Management Authority (NDMA)**. Following points are relevant w.r.t. NDMA: -

(a) The IMD, CWC and INCOIS are already integrated on Common Alerting Protocol (CAP), the integrated alerting system. The alert generating agencies will generate geo targets in regional vernacular alert for Cyclones and Tsunami and pass it to CAP platform. The concerned SDMA (Alert Authorisation Agency) will then disseminate the Alert through various alert dissemination agencies like Telecom Operators, Satellite message broadcasters (like Airport Authority of India for GAGAN and ISRO for NaviC), RSS feed, Internet Browser notification system for reachability to the public.

(b) NDMA issues advisories to the relevant states before the arrival of cyclones, containing clear Do's and Don'ts. All relevant State and District Authorities are expected to adhere to these advisories.

(c) All relevant State and District Administrations should also comply with the cyclone guidelines issued by NDMA.

(d) NDMA, through the National Cyclone Risk Mitigation Project (NCRMP), has developed a web-based Decision Support System named Web-DCRA. This system provides real-time information on various aspects related to cyclones, such as cyclone-induced flood inundation, storm surge, wave height, expected damage, and loss in each village. All District Magistrates have access to this system and should utilize it diligently to guide their actions accordingly.

16. **Central Industrial Security Force (CISF)**. CISF is tasked with assisting ports in cyclone preparedness. All sea-going assets of CISF are to be kept on standby for close coast Search and Rescue (SAR) operations.

17. **State/UT Administration**. State/UT/District Emergency Operation Centres (EOC) are to activate emergency operation centres to disseminate information pertaining to cyclones to all relevant users. Information dissemination should occur through All India Radio, group messaging, fishermen unions, etc. Furthermore, Coastal States/UTs/Fisheries authorities are advised to instruct fisher folks not to venture into the sea for fishing activities and to implement precautionary measures to advise fishermen operating at sea to return to safety or total suspension of fishing.

18. **DG Shipping**.

(a) The Directorate General of Shipping (DG Shipping) is to issue advisories to all major and non-major ports to implement and comply with requisite preventive measures for cyclone response, as per the Ministry of Ports, Shipping, and Waterways (MoPSW) checklist. The compliance report is to be forwarded to DGCOMM. DG Shipping is to keep the Emergency Towing Vessel (ETV) on standby for emergency response. Real-time information sharing is to be conducted with Maritime Rescue Coordination Centres (MRCCs). Furthermore, issuance of towing permission can be avoided in cyclone scenarios.

(b) **Implementation of Preventive Measures for Cyclone by Ports**. For non-major ports, it is the responsibility of the State Authorities and/or Maritime Boards, and for major ports, it is the responsibility of the respective Port Authority, to implement all necessary preventive measures. While the Directorate General of Shipping coordinates among various authorities, ensuring that the required preventive measures are implemented on the ground is the responsibility of the entities mentioned above.

19. **Dept. of Telecommunication**. The Department of Telecommunications (DoT) is responsible for assisting the India Meteorological Department (IMD) and all other agencies in information dissemination during cyclone response preparedness and cyclone response operations.

CHAPTER-3

EARLY WARNING MECHANISM

CHAPTER-3

EARLY WARNING MECHANISM

1. Natural hazards, such as hydro-meteorological events, occur in all parts of the world, although some regions are more vulnerable than others. Hazards become disasters when lives and livelihoods are destroyed. Further, human and material losses caused by disasters are major obstacles to sustainable development. By developing a system for issuing accurate forecasts and warnings in a format that is rapidly understood, lives and property can be protected. The World Meteorological Organization (WMO) coordinates the efforts of national meteorological services to mitigate human and property losses through improved early warning services, risk assessments, and raising public awareness of the risks and vulnerabilities associated with cyclones.

2. Early warning in the context of cyclones is a short-term mitigation measure. It involves detecting the system, continuous monitoring, prediction, formulating warnings, identifying threat & risk areas & populations, expected damages and communicating warnings with lead time and clarity alongwith suggested actions for effective mitigation, minimizing losses to life and property.

3. **Common Alerting Protocol**. India is vulnerable to a wide range of natural hazards. Here we are particularly talking about Cyclones and Tsunami. The impact of natural hazards is sinking of vessels, damage to offsore terminals, disruption in maritime traffic, damage to jetty/Harbour, oil spills, Anchor breaking, loss of life and property at sea and offshore etc. Nearly a million people have been killed over the last decade by these disasters with significant personal, material and economic strain on individuals, communities and impact on the fiscal capacity of all levels of governments. In most of the cases, the loss of human lives could have been avoided with proper precautions and measures such as timely dissemination of disaster alerts to the people of the affected area. Awareness regarding possible disasters would enable people to act timely and reduce the possibility of harm, loss or risk.

4. National Disaster Management Authority (NDMA), under Ministry of Home Affairs (MHA) has implemented Common Alerting Protocol (CAP) compliant integrated alert system for geo targeted in reginal vernacular dissemination of disaster alerts through various media. CAP seamlessly and interoperably exchanging all-hazard emergency alerts and public warnings over various kinds of network and among different stakeholders. CAP allows a consistent warning message to be disseminated simultaneously over many different warning systems, thus increasing warning effectiveness while simplifying the warning task.

5. The NDMA CAP Integrated Alert System integrates all major Alert Generating Agencies of India including IMD, CWC and INCOIS for generating alerts in the system based on their forecasts which are geo targeted in reginal vernacular for dissemination. It also integrates 36 State/UTs level Disaster Management Authorities

as Alert Authorisation agencies for authorisation of alerts prior to dissemination. Various Alert Dissemination Agencies like Telecom Operators, Satellite message broadcasters (like Airport Authority of India for GAGAN and ISRO for NaviC), are integrated with the CAP Integrated Alert System. Alerts are also being disseminated through Mobile Application, Public Portal, RSS feed, Internet Browser Notification system for reachability to the public. A single alert can trigger a wide variety of public warning systems, increasing the likelihood that intended recipients received the alert by one or more communication pathways.

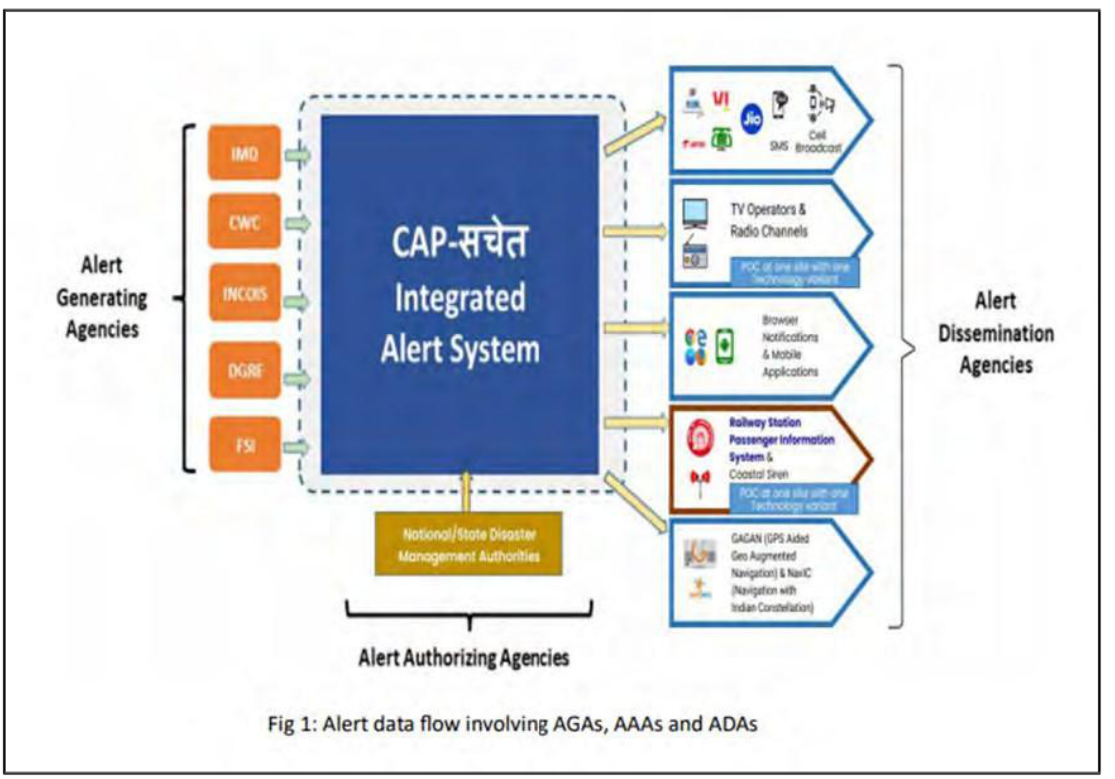


Fig 1: Alert data flow involving AGAs, AAAs and ADAs

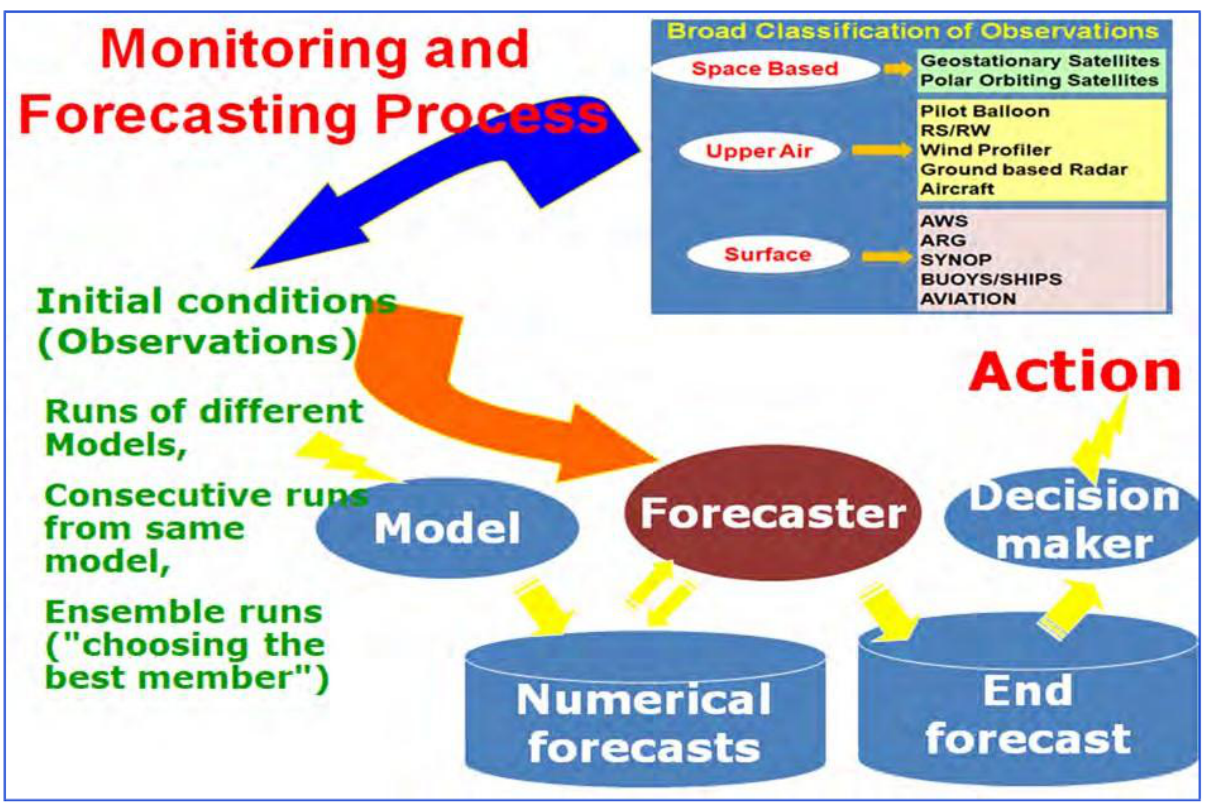
6. **Observation Network**. Cyclones in the North Indian Ocean (NIO) Basin are monitored using land-based, ocean-based, and space-based observational systems. These include meteorological observations from conventional and automatic weather stations, high wind speed recorders, observations from, ships, & ocean data buoys, coastal radars (conventional and Doppler), and national and international satellites (geostationary and polar orbiting)

7. **Cyclone Warning Generation**. The India Meteorological Department (IMD) serves as the nodal agency in India for providing cyclone warnings through its CWD and Area Cyclone Warning Centres (ACWCs) located in Kolkata, Chennai, and Mumbai, as well as the Cyclone Warning Centres (CWCs) in Visakhapatnam, Bhubaneswar, Thiruvananthapuram and Ahmedabad. The cyclone warning process is coordinated by the CWD. The CWD has been designated as a Regional Specialized Meteorological Centre (RSMC) for Tropical Cyclones (TCs) based on its capabilities and available facilities. It is one of six such centres globally, with the others being RSMC-Miami, RSMC-Honolulu (USA), RSMC-Tokyo (Japan), RSMC-St. Denis (La

Reunion), and RSMC-Nadi (Fiji), recognized by the World Meteorological Organization (WMO) under a global system of cyclone warnings. The RSMC New Delhi is mandated to provide advisories associated with cyclonic disturbances to 13 countries bordering the Bay of Bengal and Arabian Sea including Thailand, Myanmar, Bangladesh, India, Sri Lanka, Maldives, Pakistan, Iran, Saudi Arabia, Qatar, United Arab Emirates, Sultanate of Oman and Yemen.

8. Doordarshan and All India Radio (AIR) stations in New Delhi receive cyclone warning information from CWD for inclusion in national broadcasts/telecasts. At state level, these advisories are disseminated by the ACWCs and CWCs. Information on cyclone warnings is provided in real-time to the Control Room in the Ministry of Home Affairs (MHA), Government of India, the National Disaster Management Authority (NDMA), as well as other ministries, departments of the Government, and cyclone-prone state governments. Furthermore, user-specific customized warnings are issued to commercial shipping lines, the merchant navy, ports, Fisheries Departments, fishermen, government agencies, all transportation services (land, ocean, and air), farmers, and others registered with IMD, AIR, Doordarshan, other TV channels, print media, and the general public.

The Early Warning System of cyclone warning in India is presented in Fig.



9. **Generation of Customised Cyclone Warning**. The India Meteorological Department follows a seamless flow of warnings in association with cyclones. In temporal scale, the advisories are issued in extended range scale for next 2 weeks

every Thursday, medium range for next 5-7 days on daily basis, short range scale for next 3-5 days on formation of depression/cyclone and very short range scale for next few hours on the day of landfall. These advisories are customized as per users requirements. The flow of forecasting and warning process is presented in Fig.

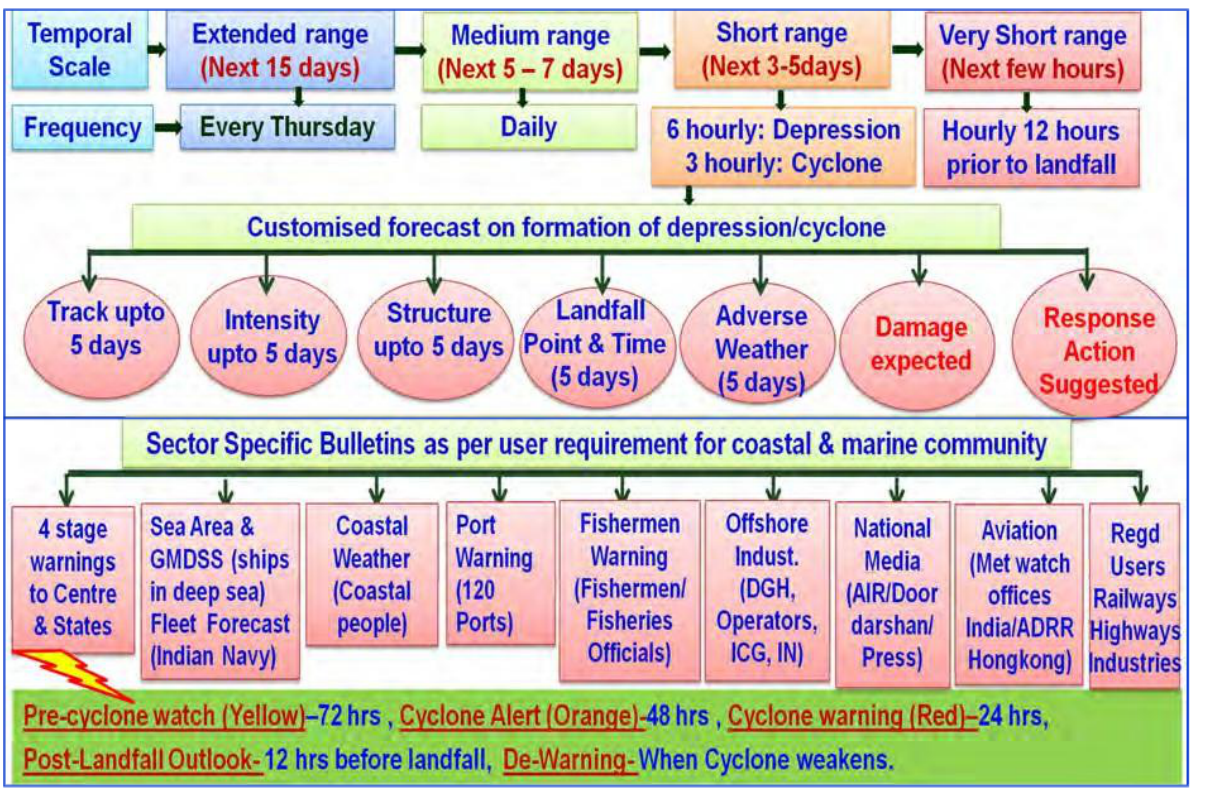


Fig. Forecasting and Warning Process of cyclones

(a) **General Agencies**. Operational agencies such as the India Meteorological Department (IMD), Indian Air Force, Indian Coast Guard, Indian Navy, Cyclone Warning Centres (CWC), Prasar Bharati, research scientists, the Central Relief Commissioner, MHA (NERC) and media personnel participate in the preparation of sector-specific multi-lingual cyclone warnings.

(b) **State-Level Agencies**. Appropriate institutional arrangements should be evolved involving the offices of IMD (State Meteorological Centres), State Disaster Management Authorities (SDMA), District Magistrate Commissioners, ACWCs, CWCs, Flood Meteorological Offices (FMO's) and other line departments for sectorial customization of cyclone impact to protect their infrastructure. Additionally, the preparation of user-friendly warnings in the local language should be facilitated to enhance community-based response.

10. **Monitoring and Forecasting of Tropical Cyclones**. The track forecast of Tropical Cyclones (TCs) is prepared using various types of numerical models. Currently, the India Meteorological Department (IMD) utilizes an array of

deterministic & ensemble numerical prediction models that are global & regional including guidance from IMD Global Forecast System (GFS), Global Ensemble Forecast System (GEFS), National Centre for Medium Range Weather Forecasting (NCMRWF) Unified Model (NCUM), NCMRWF Ensemble Prediction System (NEPS), guidance from models models available from international centres under bilateral arrangement like United Kingdom Meteorological Office (UKMO), the European Centre for Medium Range Weather Forecasting (ECMWF), National Centre for Environment Prediction (NCEP) GFS, regional model like Weather Research & Forecast (WRF) & cyclone specific model Hurricane WRF (HWRF) to prepare track forecast. IMD utilizes multi model ensemble technique (MME) for preparation of track forecast. In addition synoptic, climatological, and empirical techniques are also utilized while deciding track. For forecasting intensity guidance from above mentioned models and IMD Statistical Intensity Prediction Model (SCIP), Rapid Intensification (RI) and Rapid Weakening (RW) models are utilized in addition to climatological and persistence based methods. For predicting storm surge, guidance from INCOIS Advanced Circulation Model (AdCirc) Model alongwith Ghosh model nomograms based on the numerical solution to the hydrodynamical equations governing motion of the Sea are utilised.

11. **Nodal Agencies for Collection of Data Related to Early Warning**.

Sl.	Type of Observation	Nodal Ministry	Nodal Agency	Agencies to be involved
(a)	Land-based observations	Ministry of Earth Sciences	IMD	DoS, CWC, State Agencies, Education Institutes, etc.
(b)	Ocean-based observations	Ministry of Earth Sciences	INCOIS	NIOT, Indian Navy, Indian Coast Guard, Ships of opportunity, International Floating Platforms, etc.
(c)	Space-based observations	Department of Space	ISRO	IMD, International satellite agencies from polar orbital and geostationary platforms
(d)	Special observations	MoES/ Department of Space	IMD/NRSA	IAF, CWC and other user agencies

Sources - Table 2.2, Chapter-2 of National Disaster Management Guidelines, Management of Cyclones published by NDMA/GoI in Apr 2008 .

12. **Global Maritime Distress Safety System (GMDSS).** Under the Global Maritime Distress and Safety System (GMDSS) scheme, India has been designated as one of the 16 services worldwide for issuing Sea Area bulletins for broadcast through GMDSS for METAREA VIII (N), covering a significant portion of the Northern Indian Ocean. As a routine practice, two GMDSS bulletins are issued at 0900 and 1800 UTC. During cyclone situations, additional bulletins (up to 4) are issued for GMDSS broadcast. These bulletins are transmitted through Safety Net System (INMARSAT). The area of responsibility and the designated National Meteorological Services for issuing weather and sea area bulletins are defined.

Additionally, IMD also issues sea area bulletins from ACWC Kolkata and Mumbai for ships in deep sea beyond 40 nm from coast through NAVTEX transmitting stations. For Arabian Sea region, these are transmitted through stations located at Veraval, Vengurla & Muttam Point. For Bay of Bengal, bulletins are transmitted through stations located at Balasore, Vakalpudi, Porto Novo & Keating Point.

13. **List of Stations issuing cyclone warning for ships on the high seas:**

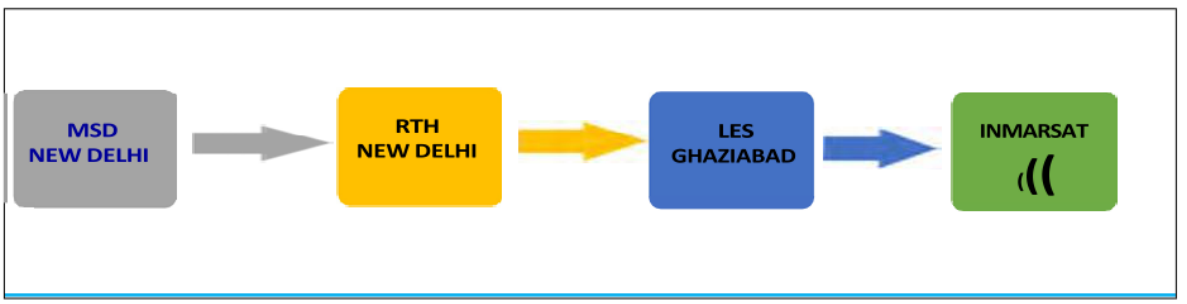
Station	Call sign of Coastal Area covered Radio Station	Area covered
Bangladesh, Chittagong	ASC	Bay of Bengal north of 18°N Latitude.
Mumbai India,	NAVTEX	Arabian Sea north of Lat. 5°N and east of Long. 60°E excluding the area north of Lat 20°N and west of Long. 68°E. The eastern boundary of the Arabian Sea for which these bulletins are issued by Mumbai is Long. 80^0E meridian excluding the Gulf of Mannar.
Kolkata India,	NAVTEX	Bay of Bengal north of Lat. 5°N except the area between the coastline on the east and the through the points 94.5°E 18°N 92°E, 13.5°N 92°E, 13.5°N 94°E, 10°N 94°E, 10°N 95°E and 5°N 95°E. The western boundary of the sea area for which bulletins are issued by Kolkata is up to and inclusive of the Gulf of Mannar (77.5°E meridian).
Chennai India,	NAVTEX	Bay of Bengal bulletins issued by ACWC Kolkata are being broadcast through Navtex Chennai by Narrow Band Direct Printing (NBDP)
Yangon Myanmar,	XYR	Bay of Bengal except area west of Long. 92°E and South of 10°N Lat.
Oman (Sultanate)	A4M	Muscat Coastal Radio Station.
Karachi Pakistan,	ASK	Arabian Sea north of 20°N, Gulf of Oman and Persian Gulf.
Colombo Sri Lanka,	4PB	Indian Ocean, Arabian Sea and Bay of Bengal from the equator to 10^0 N between 60^0 E and 95^0 E. The area 50^0 N to 10^0 N between 60^0 E and 95^0 E is an overlap with India.
Bangkok Thailand,	HSS	Gulf of Thailand, west of southern Thailand Strait of Malacca and South China Sea.
Sources - Chapter-6 of Cyclone Warning in India, Standard Operating Procedure published by IMD/MoES/GoI in Mar 2024~~1~~.		

(Area of responsibility and designated National Meteorological Services for the issue of warnings and weather and sea bulletins for the GMDSS).

14. **Transmission of GMDSS bulletin**. India is one of the issuing services of MET AREA VIII (N) among the 16 issuing services of the WMO Marine broadcast system under the GMDSS. The bulletins for ships in deep sea are prepared by Marine

Weather Services Division, RSMC New Delhi for the Indian Ocean region to the North of equator under Met Area (VIII N). MSD, New Delhi transmits it to the Information System and Services Division (ISSD) (Regional Telecommunication Hub (RTH) in New Delhi) for further transmission to INMARSAT through the Local Earth Station (LES), Bharat Sanchar Nigam Limited (BSNL) Ghaziabad.

Transmission of GMDSS Bulletin:



15. **Frequency of Broadcasts**. To begin with, as a routine, only one GMDSS bulletin for METAREA VIII (N) was broadcast at 0900 UTC. From October 1998, IMD commenced broadcast of second bulletin also at 1800 UTC. During cyclone situations, additional bulletins (up to 4) are also issued for GMDSS broadcast depending on the requirement.

16. **Bulletin for India Coasts**. There are four Stages of 'Warning Bulletin' issued by Cyclone Warning Division, AWCs and ACWCs. Bulletin for India coast is issued in different stages as mentioned below:

(a) Pre-cyclone watch,
(b) Cyclone alert,
(c) Cyclone warning,
(d) Post landfall outlook
(e) De-warning

17. These bulletins are issued from the stage of low pressure/ depression onwards. During the low pressure stage, it is issued once a day based on 03 UTC and five times a day from the stage of depression/deep depression, bulletins are issued based on 00, 03, 06, 12, and 18 UTC observations. When the system intensifies into a cyclonic storm over the North Indian Ocean, bulletins are issued at 00, 03, 06, 09, 12, 15, 18, and 21 UTC (every three-hour interval) based on previous observations. This bulletin contains the present status of the system, i.e., location, intensity, past movement, forecast intensity & movement for the next 120 hours or until the system weakens into a low-pressure area, likely landfall point & time, and likely adverse weather including heavy rain, gale wind & storm surge. Expected damage and suggested actions are also included in the bulletins. This bulletin is primarily intended for national users.

18. At the national level, cyclone warnings are provided on a real-time basis to the Control Room in the Ministry of Home Affairs, Government of India, in addition to other Ministries & Departments of the Central Government. This division provides cyclone warning bulletins to Doordarshan and All India Radio (AIR) Private radio & TV Channels for inclusion in the national broadcast/telecast. Bulletins are also disseminated to other electronic and print media and concerned state governments and other stakeholders.

19. Different colour codes have been used since the post-monsoon season of 2006 at different stages of the cyclone warning bulletins (cyclone alert-yellow, cyclone warning-orange, and post-landfall outlook-red), as desired by the National Disaster Management to indicate the priority of message.

20. **Description of the Bulletin contains the following**:

(a) Date and time of issue
(b) Current location and intensity
(c) Past Movement
(d) Maximum Sustained Surface wind (MSW)

21. **User specific bulletins issued by ACWCs/CWCs**. The ACWCs/CWCs issue warnings to ships in the high seas, ships in coastal waters, ports, fishermen, government officials, print & electronic media and the general public regarding adverse weather likely to be experienced in their respective areas. The bulletins and warnings issued by ACWCs/CWCs for their respective areas of responsibility include:-

(a) Four stage warning bulletins
(b) Sea area bulletins for ships plying in High Seas
(c) Coastal weather bulletins for ships plying in coastal waters
(d) Bulletins for Indian Navy
(e) Port Warnings
(f) Fisheries Warnings
(g) Four stage warnings for Central and State Govt. Officials
(h) Bulletins for broadcast through AIRS for general public
(j) Warning for registered users including Indian Railways, National Highways,
(k) Bulletins for press
(l) Warnings for Aviation (issued by concerned Aviation Meteorological Offices).

22. **Four Stage Warning Bulletin**. The most important warning for disaster management is the one issued to government officials under a four-stage warning system. The First Stage warning known as "**PRE-CYCLONE WATCH**" is issued

72 hours in advance of the commencement of adverse weather and contains early warning about the development of a cyclonic disturbance in the NIO, its likely intensification into a TC, and the coastal belt likely to experience adverse weather. The Second Stage warning known as "**CYCLONE ALERT**" is issued at least 48 hrs in advance of the expected commencement of adverse weather over the coastal areas. It contains information on the location and intensity of the storm, likely direction of its movement, intensification, coastal districts likely to experience adverse weather, and advice to fishermen, the general public, media, and disaster managers. The Third Stage warning known as "**CYCLONE WARNING**" is issued at least 24 hours in advance of the expected commencement of adverse weather over the coastal areas. These warnings give the latest position of the cyclone and its intensity, likely point and time of landfall, associated heavy rainfall, strong wind and storm surge along with their impact and advice to the general public, media, fishermen, and disaster managers. The Fourth Stage of warning known as "**POST LANDFALL OUTLOOK**" is issued at least 12 hours in advance of the expected time of landfall. It gives the likely direction of movement of the cyclone after its landfall and the adverse weather likely to be experienced in the interior areas. However, this is applicable for the TCs developing over the open sea like the central Bay of Bengal or Arabian Sea. It is not applicable to the systems developing in landlocked areas or near the coast and under rapidly intensifying scenarios. In such situations, a Cyclone Alert can be issued directly without issuing the Pre-Cyclone Watch, and Cyclone Warning can be issued directly without issuing Cyclone Alert. The genesis, location, its distance from the expected coast, and the expected number of days in which landfall is expected will decide the possibilities of utilising all stages of cyclone warning as per SOP. All the above warnings are issued by CWD and ACWCs/CWCs.

23. **Sea Area Bulletin**. Sea area bulletins for the Bay of Bengal are issued by ACWC Kolkata and are broadcast by the coastal radio stations at Kolkata (VWC) and Chennai (VWM), while those for the Arabian Sea are issued by ACWC Mumbai and broadcast by the coastal radio station at Mumbai (VWB). These bulletins cover the area of responsibility assigned to India by the World Meteorological Organisation (WMO).

24. During undisturbed weather, only two bulletins are issued per day, known as Daily bulletins. In the event of disturbed weather, a third bulletin known as Extra is broadcast, if considered necessary. However, when a depression has actually formed, the Extra bulletin must be issued based on 1800 UTC observations. When a cyclonic storm has developed, every attempt should be made to broadcast three additional bulletins a day. The three additional bulletins are known as Storm bulletins, which together with the three bulletins mentioned earlier, make up a total of six bulletins a day. The Storm GASBAG bulletin (1500 UTC) should be issued on a routine basis during a cyclone situation. These bulletins are broadcast at fixed hours according to a schedule. In addition, if any unexpected development of weather warrants urgent communication to ships, in between scheduled broadcasts, it is broadcast in the form of a special bulletin, called Hexagon, which should be issued immediately after the development is noticed.

25. **Warning for Fisheries**. Warnings for fishing interests are issued by the MSD/ACWCs/CWCs whenever (i) the wind speed is expected to exceed 45 km/h (i.e., for squally weather, gales, strong monsoon, and offshore winds) (ii) the state of the sea is very rough or above and (iii) expected swell and (iv) depression and above intensity cyclonic disturbance over the Bay of Bengal and the Arabian Sea. These warnings are transmitted by telephone /Fax/email to the AIR stations (about 30 in number) in the maritime states. These warnings are broadcast as a routine four times a day (morning, mid-day, evening, and night) from the AIR stations in the local language. During a cyclonic storm, such warnings are covered in the cyclone bulletins sent to the AIR stations at hourly or 3-hourly intervals for frequent broadcast. The fishermen can listen to these broadcasts through portable radio receiving sets. The warnings are also disseminated through SMS by IMD & INCOIS network and mobile apps. The fishermen warnings are issued for entire North Indian Ocean once a day valid for next five days by MSD under normal conditions and 6 times a day during cyclone period.

26. **Customised Location Specific Warnings for offshore industries/Ports/Indian Coast Guard Locations/Indian Air Force coastal Stations**. IMD commenced customised location specific bulletins for offshore locations since October 2022. The services further expanded to other sectors including Ports/Indian Coast Guard Locations/Indian Air Force coastal Stations by 2024. This bulletin is issued in case of cyclonic disturbances likely to intensify into a cyclone. The customised bulletins are issued every six hourly from the stage of depression and every three hourly from cyclone stage till landfall/weakening into a deep depression. The bulletin contains following information:-

(a) **Subjective information** about the cyclonic disturbance,

(b) **General information** in tabular form about (i) forecast location, (ii) intensity, (iii) wind distribution around the centre of the system corresponding to the winds in the range of 28-33 kt, 34-49 kt, 50-63 kt and ≥64 kt, (iv) significant wave height and (v) state of sea and uncertainty in path & intensity.

(c) **Customised information** in tabular form about the **time of arrival of cyclone nearest to rig**, corresponding nearest distance, intensity, state of sea and uncertainty in path & intensity alongwith color coded impact on rig as green (no action), yellow (be updated), orange (be prepared) & red (take action).

(d) **Graphical products** including observed and forecast track alngwith cone of uncertainty & wind distribution and rig locations.

27. **Terminology of Bulletin**. Bulletin terminology w.r.t Sea State, Distribution of Rainfall and Intensity of Rainfall are tabulated below:-

(a) **State of Sea**

Descriptive Term	Significant Wave Height in Meters	Wind Speed Knots/Kmph	In Beaufort Scale
Calm (Glassy)	**0**	**0**	**0**
Calm (Rippled)	**0-0.1**	**1-3/ (2-6)**	**1**
Smooth (Wave less)	**0.1-0.5**	**4-10 /(7-19)**	**2-3**
Slight	**0.5-1.25**	**11-16 /(20-30)**	**4**
Moderate	**1.25-2.5**	**17-21/ (31-39)**	**5**
Rough	**2.5-4.0**	**22-27 /(41-50)**	**6**
Very rough	**4.0-6.0**	**28-33/(52-61)**	**7**
High	**6.0-9.0**	**34-40/(63-74)**	**8**
Very high	**9.0-14.0**	**41-63/(76-117)**	**9-11**
Phenomenal	**Over 14**	**64 or above (119 or above)**	**12**

***Sources** - Table 6.10 , Chapter-6 of Cyclone Warning in India, Standard Operating Procedure published by IMD/MoES/GoI in Mar 2021.*

(b) **Distribution of Rainfall**

Distribution	No. of Places	Description
Isolated	Isolated/ One or two places	<25% of area gets rainfall
Scattered	A few places	(26-50)% of area gets rainfall
Fairly widespread	Many Places	(51-75) % of area gets rainfall
Widespread	Most places	(76-100)% of area gets rainfall

***Sources** - Table 6.11, Chapter-6 of Cyclone Warning in India, Standard Operating Procedure published by IMD/MoES/GoI in Mar 2021.*

(c) **Intensity of Rainfall**

Descriptive Terms	Rainfall amount in mm
No rain	00
Very light rain	0.1-2.4
Light rain	2.5-15.5
Moderate rain	15.6-64.4
Heavy rain	64.5-115.5
Very heavy rain	115.6-204.4
Extremely heavy rain	204.5 or more
Exceptionally heavy rain	When the amount is a value near about highest recorded rainfall at or near the station for the month or season. However, this term will be used only when the actual rainfall amount exceeds 12 cm.

***Sources** - Table 6.10 , Chapter-6 of Cyclone Warning in India, Standard Operating Procedure published by IMD/MoES/GoI in Mar 2021.*

CHAPTER-4

PREPAREDNESS AND RESPONSE

CHAPTER-4

PREPAREDNESS AND RESPONSE

OPERATIONAL GUIDELINES FOR RESPONSE DURING CYCLONIC DISTURBANCES

1. India lies in the cyclone-prone belt, with the East coast being more vulnerable to cyclone hazards than the West coast. The coastal areas are further affected by the Southwest Monsoon and Northeast Monsoon. The Southwest monsoon generally sets in the A&N islands in mid-May and over the mainland in early June, characterized by rough to very rough seas and heavy rainfall over the west coast. The Northeast monsoon, which is the retreating phase of the Southwest monsoon, generally sets during early October till December and primarily affects the Southern peninsula. The Southwest monsoon accounts for 75% of the total rainfall over the Indian Subcontinent. In addition, various dynamic local weather phenomena such as 'Elephanta,' affecting the Malabar coast during the months of September-October, and 'Nor Westers' (Kaal Baisakhi), affecting the Northeast coast from March-May, are also witnessed. Cyclones, monsoon conditions, and local weather phenomena are associated with strong winds, rough seas, and heavy rainfall with the potential for severe damage to coastal areas and risk to the lives of mariners.

2. Cyclonic disturbances, occurring at more frequent intervals in the Indian Subcontinent region, have led to far-reaching consequences on the fishing and coastal communities. The large-scale catastrophe caused during cyclones remains unparalleled and has brought Maritime SAR into the public domain. This has reinforced the criticality of Maritime SAR and disaster relief requirements during such contingencies.

3. Considering the perspectives of stakeholder responsibilities and expectations, broad operational guidelines for response during such contingencies have been formulated and enumerated.

4. These operational guidelines are intended to assist maritime stakeholders' operational authorities for smooth execution/response during cyclonic disturbances/disasters in their respective AORs. It is imperative that all stakeholders/agencies generate primary responses for all categories of cyclones for the safety of respective assets/concerned human resources. The following points shall form the basis for the agency-specific checklist:-

CONTINGENCY ACTIONS (POLICY /PREPARATION)		
Ser.	**Action**	**Agency**
(a)	Conduct of mock exercises to validate SOPs and check coordination mechanism.	All Concerned Agencies
(b)	IMD (i) conducts pre-cyclone exercise meeting twice in a year in April and September with participation of user agencies including ICG, (ii) Updates contact details for receiving bulletin by email & SMS, (iii) Meteorological Observations from ICG and *IN* to be shared with IMD, (IMD to provide format for rendering such details) (iv) Requirement , if any to be submitted to IMD	All concerned Agencies/ ICG/ *IN*
(c)	Special Community Interaction Program (CIP) is to be undertaken by all concern agencies in coastal villages/fishing villages to spread awareness on various safety aspects.	All Concerned Agencies
(d)	Areas of dense fishing activity may be identified in order to shepherd/ mitigate SAR operation in case of deterioration/ intensification of the weather conditions.	ICG/*IN*
(e)	Department of fisheries to undertake preventive checks of fishing boat in term of hull, safety gears and advise fishing community not to operate during rough weather warning. Fisheries Authorities and Fishermen Association be impressed upon following under intimation to state authorities:- (i) To Chalk out probable areas of operation of fishing boats. (ii) To maintain account of fishing boats and carry out safety equipment inspection. (iii) Verification of mechanism onboard fishing vessels for receiving alert and their safe return. (iv)	Fisheries Department
(f)	Formulation of organisation specific SOPs.	All Agencies
***Note** : NDMA cyclone advisory template is placed at **Appendix 'C'** for preparatory actions by SDMAs, DDMAs, local governing bodies, emergency support function organisation and concerned stakeholders.*		

ACTIONS ON ISSUE OF CYCLONE WARNING		
Ser.	**Action**	**Agency**
(a)	Closely monitor the cyclogenesis forecast and subsequent advisories at various stages of development of cyclone till its dissipation by IMD and various other agencies through various sources. In addition IMD to provide forecast to ISRO (for dissemination to DAT-SG through its control centre), DGH and Oil Industry Safety Directorate as per MoU.	All concerned
(b)	Maintain highest level of operational readiness of respective assets to mitigate/ respond to emergent maritime SAR and disaster relief contingencies.	All concerned
(c)	Institute appropriate safety measures for assets in the likely affected areas.	All concerned
(d)	Sea going units of all concerned agencies to be put on high alert and kept standby for deployment towards impending response measures.	ICG/*IN*/Marine Police/Indian Customs and Marine agencies
(e)	Weather advisory to be given to all fishermen/fishing communities/coastal villages.	State/UT Administration/ fisheries Department
(f)	Promulgation of VHF warnings to fishermen at sea by ICG/*IN* surface/Air assets.	ICG/*IN*
(g)	Weather advisory broadcast through Coastal Surveillance Network.	ICG
(h)	Activation of ISN/ SAR warning on NAVTEX as required. Other SAR coordination at sea, as required.	ICG/MRCC
(j)	Requirement of additional manpower and resources for response and relief measures are to be appreciated and worked out in advance.	All Agencies State-UT Administration
(k)	State-UT/District Emergency Operating Centre (EOC) to activate Emergency Operating Centre to disseminate information. The information dissemination should be through All India Radio, Group messaging, NGOs, Fishermen Union etc.	State-UT Administration/ Fisheries Dept.

(l)	Coastal States/ UTs/ local Fisheries Authorities to direct fisher folks not to venture into sea for fishing activities and institute precautionary measures to advice fishermen operating at sea to return to the safety.	State-UT Administration/ Fisheries Dept.
(m)	Port Authorities/ VTMS for necessary precaution, preparedness and safety measures in their area of responsibility including safety of vessels at anchorage & derelicts keeping DG Shipping informed.	Port Authority DG Shipping/ MMD
(n)	A Single Point of Contact (SPoC) may be established vide MHA guidelines at each level for speedy communications and exchange of information. Communication group may be formed, if appropriate. The details of Single Point of Contact (PoC) should be available with State Administration.	State-UT Administration/ Fisheries Dept./ Ports/ Indian Customs/CISF/ All concerned Agencies
(p)	Safety in ODA including platforms and vessels engaged in ODA.	OHA/DGH/OISD
Note: ***On receipt of Cyclone warning from IMD, all agencies shall initiate preventative action and disseminate cyclone warning and regular updates to all entities at sea and coastal areas***.		

ACTIONS DURING CYCLONE		
Ser.	**Action**	**Agency**
(a)	Closely monitor the Cyclone movement and weather forecasts to advise all concerned authorities for prompt appropriate response actions.	All Agencies
(b)	Deploy additional units / task deployed units for weather warning dissemination, shepherding fishermen to safety and response to Search and Rescue requirements at sea. DGS to deploy ETV as required.	ICG/*IN*/ Indian Customs/ Port/, OHAs (All agencies having sea going assets in their respective AoR).
(c)	Intensify weather broadcast and advisories in local languages for guiding fishermen and mariners for safety. Additional options to relay/ broadcast messages through other sources/ agencies be also coordinated.	ICG/*IN*
(d)	MRCC to reinforce promulgation of safety message through ISN/ NAVTEX and also coordinate promulgation of NAVAREA to caution mariners with request to advise fishermen for safety as appropriate.	MRCC/ICG/ Navarea-VIII Coordinator
(e)	A high level of operational readiness be maintained for coordination of Search and Rescue requirements at sea. All resource agencies as per NMSAR Manual and guidelines to provide resources. Primary response is to be generated by operator/ agency/administration.	MRCC/ICG/All concerned
(f)	Activate Core Group/ Coordination Cell for close liaison and coordination with State/ UT/ Local & Civil Administrative and Fisheries Authorities.	Local Administration
(g)	Integrate State/ UT/ District/ local Disaster/ Emergency response authorities and centres for rescue and relief contingencies.	State Administration
(h)	In case of launch of a large scale and extended Maritime Search and Rescue efforts, the Operation to be coordinated by MRCC.	ICG/MRCC
(j)	MRCC being repository of information, units at sea to forward operational details and photographs of the operations undertaken to concerned MRSCs/ MRCC by fastest means.	All concerned

(k)	State fisheries authorities to coordinate with all concerned regarding accounting of all fishing boat. Port Authorities to coordinate with all concerned for accounting of small vessels. Post accounting, details of missing boats / vessels, if any, to be provided to MRCC.	Department of Fisheries/Port Authority/ Administration.
(l)	Maintain seamless communication with all the participating and resource agencies and at all level. Prompt information sharing with MRCC/MRSCs is to be undertaken.	All concerned
(m)	In case of Cyclone affecting the Island Territories, deploying ICG/*IN*/IAF Units for transportation of essential commodities, food, medical and relief items may be appreciated depending on requirements and factored in the Operational Planning.	ICG/*IN*/IAF UT/State Administration
(n)	Shore based medical assistance may be undertaken in coordination with State and local medical authorities.	UT/State Administration
(p)	MRCC to consider liaison with MRCCs of neighbouring countries for Search and Rescue assistance to stranded fishermen and relaying alert messages in their AOR, If required.	ICG/MRCC
(q)	Search, rescue and relief operations by units may be scaled down/ terminated in consultation /information to MRCC.	All Agencies

POST CYCLONE OPERATIONS		
Ser.	**Action**	**Agency**
(a)	The Department of Fisheries to account for the fishing boats (FBs), and details of missing FBs must be promptly communicated to MRCC and Navarea-VIII Coordinator. Comprehensive information about FBs, including their "Last Known Position" (LKP), should be provided for the dissemination of safety information.	ICG/*IN*/ Fisheries Department
(b)	MRCC to activate ISN, if required.	ICG-MRCC
(c)	NAVAREA -VIII Coordinator to promulgate NAVAREA for look out for missing Fishing Boats / other small vessels. Department of Fisheries to intimate MRCC regarding return of missing Fishing Boats/ Fisherman. Port Authorities to intimate status of other missing vessels.	Department of Fisheries, IN, ICG-MRCC/ Administration/ Port Authorities
(d)	The details of missing FBs/Fisherman to be shared with all state/UTs Administration/ICG/*IN*.	Department of Fisheries
(f)	All ICG/ IN ships and aircraft on patrol to monitor AoR for any distressed vessel.	ICG/ *IN*
(g)	All sectors to prepare and share report on early warnings by IMD & forecast performance of IMD, timeliness of warnings by IMD, utility of advisories, users feedback and damage report.	All agencies

Note: Contact details of key stakeholders are placed at Appendix 'A'

5. **Documentation**

(a) All agencies are to maintain records of all operations undertaken during cyclone response.

(b) A proper diary of events is to be maintained; detailing actions taken along with outcomes.

(c) Detailed reports, along with statistics and photographs, are to be maintained and shared with other agencies if required.

(d) Since MRCCs are repositories of all information pertaining to M-SAR, details of any M-SAR Ops are to be shared with MRCCs by all stakeholders.

6. **Miscellaneous**

(a) Maintain/manage efficient media management and issue regular press releases/updates regarding the actions/update of respective agencies.

(b) Communicate with media according to departmental PR policy.

(c) It is the responsibility of Port Authorities/State Authorities, and State Maritime Boards to ensure that timely weather advisories/instructions are issued to vessels in and around their areas, advising them to move to safe/sheltered areas well in advance. Ports need to provide shelter to high- risk vessels and fishing boats requesting assistance/shelter.

(d) For vessels at Offshore Development Areas (ODA) and offshore installations, it is the responsibility of DGH/OISD/Oil & Gas (E&P) operators to ensure that timely advisories/instructions are issued to the vessels (owned/contracted) through operators/contractors via established communication channels in their area. The aim is to ensure that such vessels can reach a safe port or safe area at sea, as necessary, well in advance. This includes small crafts such as crew boats, mooring boats, etc., which need to reach the nearest safe port promptly.

(e) For personnel on board platforms in the ODA, it is the responsibility of Oil & Gas (E&P) operators to ensure that all non-essential personnel are evacuated well in time as per ERP. If it is decided that certain non-essential personnel are required to remain on the platform, a thorough risk assessment needs to be conducted by the Oil & Gas (E&P) operator as per their ERP, and the same needs to be reviewed under rule 169(a) of P&NG (Safety in offshore operations) Rules 2008. MRCC/ICG should be informed about the same.

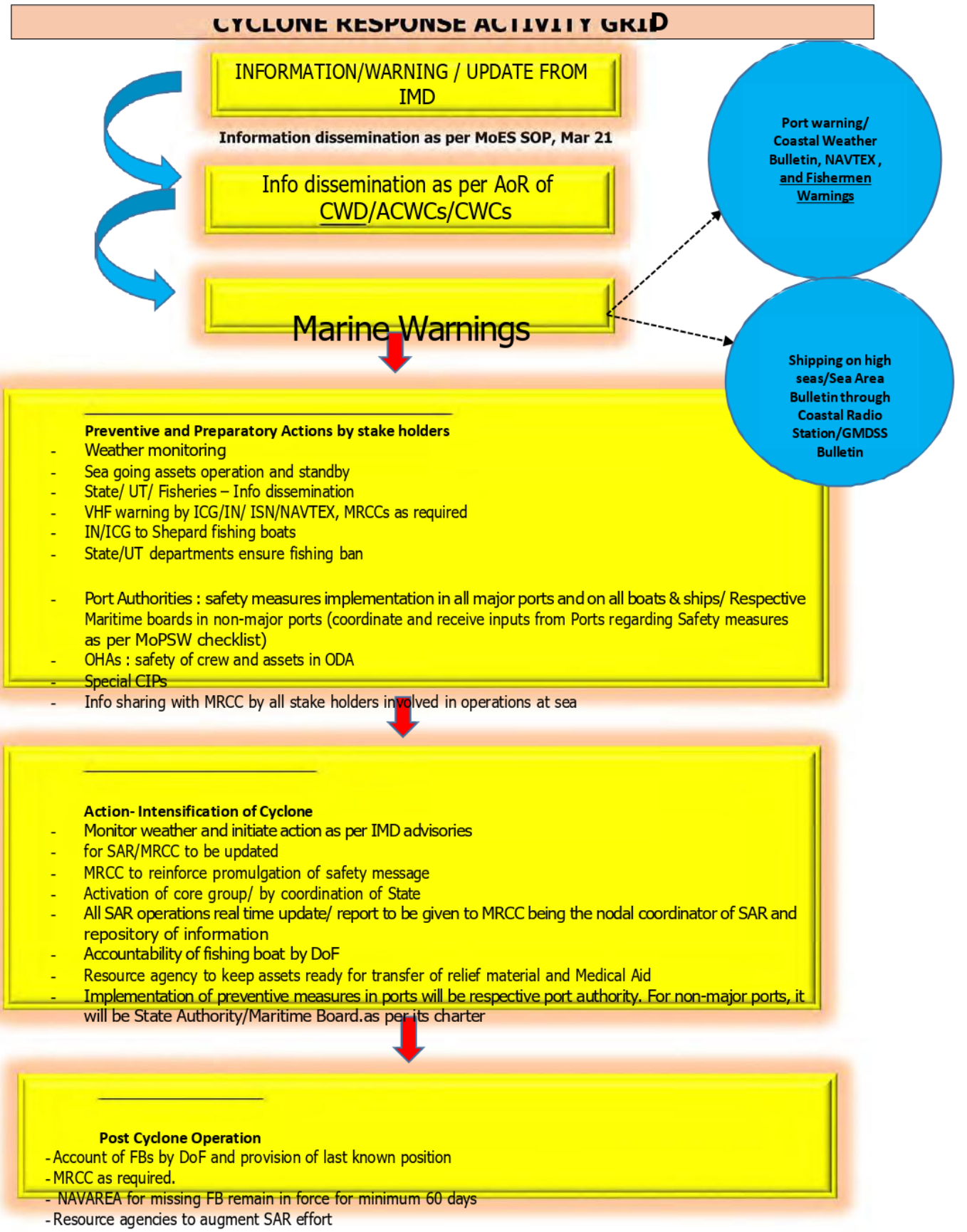
(Rule no. 169 (a) of P&NG (Safety in offshore operations) Rules, 2008 states that "The operator shall ensure safe working in adverse weather and tidal conditions and identify the rough weather conditions when operations are to be discontinued and evacuations carried out, as required. The window of closure during Cyclones & Tsunamis should be prepared by the operators based on the design and sustainability of offshore installations and risk assessment. Furthermore, specific/customized SOPs are recommended to be promulgated by OISD.")
Note : DGH/OISD to monitor above activities, as required.

(f) Regarding the request for a place of refuge, if sought by any vessel, competent authority of a port may decide on the request for a place of refuge, prioritising national interest after taking inputs from a standing committee comprising DGS, MoPSW, Indian Coast Guard, Indian Navy and competent authority of the respective port. DGS to form such standing committee and promulgate details to concerned stakeholders.

(g) Rule 169 (a) of P&NG (Safety in offshore operations) Rules, 2008 states that "The operator shall ensure safe working in adverse weather and tidal conditions and identify the rough weather conditions when operations are to be discontinued and evacuations carried out, as required." Depending on the complexity of the operations and the time required to shut down operations during rough weather, operators will be the best judge to decide on keeping non-essential personnel in all scenarios based on the emergency response plan. However, MoPNG/ DGS/ DGH & OISD to review actions taken by operators.

(h) To ensure safe operations, suitable vessels for assistance are required to be stationed at oil handling agency platforms. The necessity of these assistance vessels will be contingent upon the scale and scope of operations of the offshore operator. The number of assistance vessels is to be determined by the operators, considering the vulnerable vessels that need to be towed / assisted during cyclonic forecasts. DGH/OISD may oversee all such actions, as required.

(j) Landward activity coordination aspects at state level with MHA/ DM Division/ NDMA-SDMA-DDMA.


CYCLONE RESPONSE ACTIVITY GRID
INFORMATION/WARNING / UPDATE FROM IMD
Information dissemination as per MoES SOP, Mar 21
Info dissemination as per AoR of CWD/ACWCs/CWCs
Marine Warnings
Port warning/ Coastal Weather Bulletin, NAVTEX, and Fishermen Warnings
Shipping on high seas/Sea Area Bulletin through Coastal Radio Station/GMDSS Bulletin
Preventive and Preparatory Actions by stake holders
- Weather monitoring
- Sea going assets operation and standby
- State/ UT/ Fisheries – Info dissemination
- VHF warning by ICG/IN/ ISN/NAVTEX, MRCCs as required
- IN/ICG to Shepard fishing boats
- State/UT departments ensure fishing ban
- Port Authorities : safety measures implementation in all major ports and on all boats & ships/ Respective Maritime boards in non-major ports (coordinate and receive inputs from Ports regarding Safety measures as per MoPSW checklist)
- OHAs : safety of crew and assets in ODA
- Special CIPs
- Info sharing with MRCC by all stake holders involved in operations at sea
Action- Intensification of Cyclone
- Monitor weather and initiate action as per IMD advisories
- for SAR/MRCC to be updated
- MRCC to reinforce promulgation of safety message
- Activation of core group/ by coordination of State
- All SAR operations real time update/ report to be given to MRCC being the nodal coordinator of SAR and repository of information
- Accountability of fishing boat by DoF
- Resource agency to keep assets ready for transfer of relief material and Medical Aid
- Implementation of preventive measures in ports will be respective port authority. For non-major ports, it will be State Authority/Maritime Board.as per its charter
Post Cyclone Operation
- Account of FBs by DoF and provision of last known position
- MRCC as required.
- NAVAREA for missing FB remain in force for minimum 60 days
- Resource agencies to augment SAR effort

SECTION : II

SOP FOR TSUNAMI RESPONSE IN MARITIME DOMAIN

CHAPTER-5

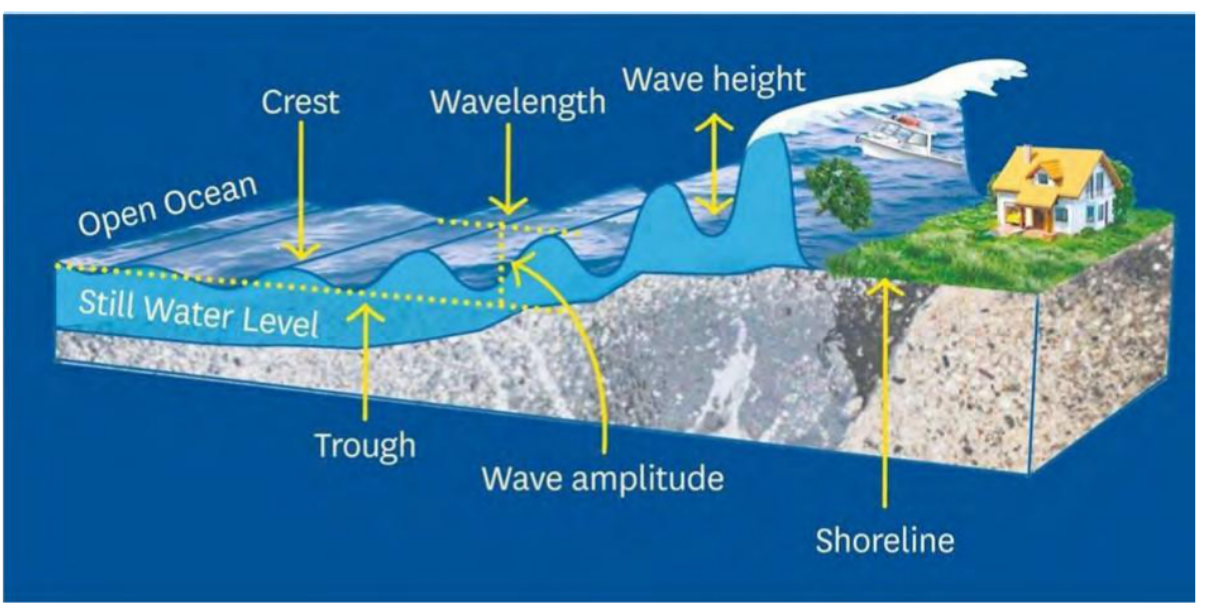
INTRODUCTION

CHAPTER-5

INTRODUCTION

1. **Tsunami**. A tsunami is a **series of waves with a long wavelength and period** (time between crests). The time between crests of the wave can vary from a few minutes to over an hour. Tsunamis are often incorrectly called tidal waves; however, they have no relation to the daily ocean tides. The term "Tsunami" is derived from the Japanese word "**tsu-nah-mee**," which means harbour wave. Tsunamis can occur at any time of day or night.

2. **How Tsunamis Generated**. Tsunamis are generated by any large, impulsive displacement of the seabed level. Earthquakes generate tsunamis by vertical movement of the seafloor; if the seafloor movement is horizontal, a tsunami is not generated. **Earthquakes of magnitude 6.5 or higher are critical for tsunami generation**. Tsunamis can also be triggered by landslides into or under the water surface and can be generated by volcanic activity and meteorite impacts.



3. **How Often Tsunamis Occur**. On average, there are about two tsunamis per year in the Pacific Ocean, occurring somewhere in the region, which can cause damage near the source. Approximately every 15 years, a destructive tsunami occurs in the Pacific. The destructive tsunami that occurred on December 26, 2004, on the Indian Coast, in terms of its impact, appears to have occurred for the first time in history in the coastal districts of India. Geological studies are expected to shed light on the recurrence of such tsunamis.

4. **How Fast a Tsunami Travel**. The velocity of a tsunami depends on the depth of water through which it travels. Tsunami velocity equals the square root of water depth (h) times the gravitational acceleration g, that is, $V = \sqrt{(gh)}$. Tsunamis

travel at approximately 700 km/h in 4000 m depth of seawater. In 10 m of water depth, the velocity drops to about 36 km/h.

5. **How Big is a Tsunami**. Tsunamis range in size from centimetres to over 30 meters in height. Most tsunamis are less than 3 meters in height. As tsunamis propagate into shallow water, the wave height can increase by over 10 times. Tsunami heights can vary greatly along a coast, as the waves are amplified by certain shoreline and bathymetric (sea floor) features.

CHAPTER-6

TSUNAMI RISK ASSESSMENT AND VULNERABILITY

CHAPTER-6

TSUNAMI RISK ASSESSMENT AND VULNERABILITY

Overview.

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 along our 7516 km long coastline. The coastal population has been increasing steadily, mostly due to the expanding scope for the 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, efforts to strengthen the preparedness of coastal communities to face increasing threats such as storm surges, sea level rise, coastal erosion, etc., have often been restricted to localized campaigns with very limited impact, despite the increasing disaster risk and vulnerability of coastal communities.

Tsunami in the Indian Sub-Continent.

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

3. Although not as frequent as in the Pacific Ocean, tsunamis generated in the Indian Ocean pose a great threat to all the countries in the region. Countries most vulnerable to tsunamis in the Indian Ocean region include Indonesia, Thailand, India, Sri Lanka, Pakistan, Iran, Malaysia, Myanmar, Maldives, and Somalia. Additionally, Bangladesh, Kenya, Madagascar, Mauritius, Oman, Reunion Island (France), Seychelles, South Africa, and Australia are also at risk. Despite the rarity of tsunamis in the Indian Ocean region, over the last 300 years, there have been 13 recorded tsunamis, with three of them occurring in the Andaman and Nicobar region. The details of the location of the epicentre, deaths, and damage caused by these tsunamis are not known. The three tsunamis that affected the 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 meters in Pakistan and resulted in the deaths of 4,000 people. Overall, the run-up levels in Indian Ocean tsunamis have varied from 1 to 13 meters. 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

Indian Ocean Tsunami of 26th December 2004

4. 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 reported missing in the tsunami-affected areas.

Lessons Learnt and Analysis of Critical Gaps

5. One of the major gaps in tsunami risk management was the lack of awareness of 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 include the lack of public awareness of tsunami risk and vulnerability in coastal areas, weak enforcement and compliance of town planning bylaws, development control regulations, and building codes in coastal areas, and challenges in the implementation of appropriate technologies to disseminate and communicate early warnings to coastal inhabitants located in the vicinity of a near-source tsunami.

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

7. 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 coastal areas

8. Planners, emergency responders, and residents in coastal areas need to understand the multi-hazard ramifications of very large local earthquakes 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 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 when making long-term planning decisions.

9. 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.

Tsunami Risk and Vulnerability in India

10. The Indian Ocean Tsunami on 26th December 2004, which devastated 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 to which coastal communities in India are exposed, even from 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 coastal communities, as well as the lack of public awareness and emergency response preparedness among various stakeholder groups, made the tsunami response more difficult and challenging.

11. 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 that underlies or borders the ocean floor. Tsunamis are also generated by volcanic eruptions and submarine landslides, nuclear explosions, and even due to the 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 historical tsunamis, earthquakes, their magnitudes, the 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 five potential source regions, namely 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 : Management of Tsunamis

12. The Disaster Management Act of 2005 envisaged a paradigm shift in the Government of India'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 mitigate the risks associated with tsunamis in coastal areas.

Recent Major International Developments

13. The Intergovernmental Coordination Group for the Tsunami Warning and Mitigation System for the Indian Ocean (ICG/IOTWMS) has been established. India played an important role in the development of IOTWMS. Upon the successful implementation of regional tsunami services, on 12th Oct 2011, the Indian Tsunami Early Warning System at ESSO-INCOIS was designated as a regional Tsunami Service Provider (TSP), entrusting it with the responsibility of providing tsunami advisories to Indian Ocean rim countries. Since then, ITEWC has been providing tsunami advisories and related services to 25 countries in the Indian Ocean Region. As part of the TSP service, India also regularly participates in communication tests and tsunami wave exercises.

Standard Operating Procedure (SOP) of ITEWC

14. ITEWC services for an earthquake event commence whenever earthquakes are recorded with magnitudes ≥ 6.5 within the Indian Ocean and magnitudes > 8.0 outside the Indian Ocean. Duty officers should respond immediately and begin their analysis of the event. The analysis includes automatic and interactive processes for determining the earthquake's epicentre, depth, and origin time, as well as its magnitude.

15. The following is a brief description of the types of bulletins issued by the Warning Centre. The bulletins/notifications issued for an event are numbered sequentially. The bulletins are identified by the header **"NTWC-INCOIS-yyyymmdd-hhmm-bulletin number (TYPEX)."**

16. For Indian Ocean earthquakes, the Warning Centre issues a Type-I bulletin that contains preliminary earthquake information and a qualitative statement on its tsunamigenic potential based on the following criteria:-

Magnitude (Mw)	Product Type
6.5≥ M ≤ 7.0	Earthquakes of this size sometimes have small potential to generate tsunamis.
≥ 7.1	Earthquakes of this size sometimes have potential to generate tsunamis.

17. Based on preliminary earthquake parameters, the nearest matching scenario from the pre-run model scenario database is selected. If the pre-run model scenario indicates Estimated Wave Amplitude (EWA) < 0.2 m, then a Type-II bulletin is issued with NO THREAT information. However, monitoring of sea-level observations continues.

18. If the Estimated Wave Amplitude is > 0.2 m, then a Type-II bulletin is issued with Estimated Time of Wave Arrival (ETA), Estimated Maximum Wave Amplitude

(EWA), and Threat Category (WARNING / ALERT / WATCH) for each of the coastal forecast zones.

19. The criteria for the generation of different threat types (WARNING / ALERT / WATCH) for a particular region of the coast are based on the available warning time (i.e., the time taken by the tsunami wave to reach the particular coast). The threat criteria are based on the premise that coastal areas falling within 60 minutes' travel time from a tsunamigenic earthquake source need to be warned based solely on earthquake information, since enough time will not be available for confirmation of water levels from tsunami buoys and tide gauges. Those coastal areas falling outside the 60 minutes' travel time from a tsunamigenic earthquake source could be put under an Alert/Watch status and upgraded to a Warning/Alert only upon confirmation from water-level data.

20. The criteria for considering an area under different Threat levels (WARNING / ALERT / WATCH) are as follows:

Pre-run Model Scenario Results			
ETA $\leq$ 60 mins		ETA > 60 mins	
EWA (m)	Threat Status	EWA (m)	Threat Status
> 2	Warning	> 2	Alert
0.5 to 2	Alert	0.5 to 2	Watch
0.2 to 0.5	Watch	0.2 to 0.5	Watch

21. If the revised earthquake parameters become available, or if the elapsed time since the earthquake exceeds 60 minutes before real-time sea-level data becomes available, a supplementary bulletin to the Type-II (Type-II Supplementary-xx) is issued with revised Threat (WARNING / ALERT / WATCH) information.

22. If a Threat (WARNING / ALERT / WATCH) is issued or if there is otherwise the possibility that a tsunami may have been generated, the Warning Centre monitors the sea level gauges such as open ocean tsunami buoys and coastal tide gauges near the epicentre.

23. If the readings from sea level gauges confirm the generation of a tsunami, the Warning Centre issues a Type-III bulletin with Threat (WARNING / ALERT / WATCH) information from model scenarios as well as observed water levels. As subsequent real-time observations become available or after 60 minutes from the time of the previous bulletin issuance, a Type-III Supplementary-xx is issued. Type-III Supplementary-xx messages also contain Threat Passed information for individual Zones.

24. The **FINAL BULLETIN** is issued when there are no significant water level changes from multiple sea level gauges or 120 minutes after the last exceedance of the 0.5 m threat threshold at the last Indian coast.

25. However, as local conditions would cause wide variation in tsunami wave action, the **ALL CLEAR** determination is made by local authorities.

Standard Operating Procedure (SOP) for Tsunami Early Warnings INCOIS

T_0 : Origin Time

Earthquake

Mag ≥ 6.5
Depth < 100km
Ocean

Type-I : T_0 + 10 min

EQ (tsunamigenic potential) Information

Type-II :T_0 + 20min

Potential Threat

Pre-run Model Scenario Database			
ETA < 60 mins		ETA > 60 mins	
EWA (M)	Threat Status	EWA (M)	Threat Status
> 2	WARNING	> 2	ALERT
0.5 to 2	ALERT	0.5 to 2	WATCH
0.2 to 0.5	WATCH	0.2 to 0.5	WATCH

Type-II-Supple : As and when revised EQ para available

Confirmed Threat

Type-III : As and When first Real-Time Observation becomes available

Real-time Water-level Observations
BPRs / Tide gauges

NO Significant Changes in Water level

Significant Changes in Water level

Type-III-Supple : As and When more Real-Time Observations become available

Estimated Threat Status	
EWA (M)	Threat Status
> 2	ALERT
0.5 to 2	WATCH
0.2 to 0.5	WATCH

Upgraded Threat Status

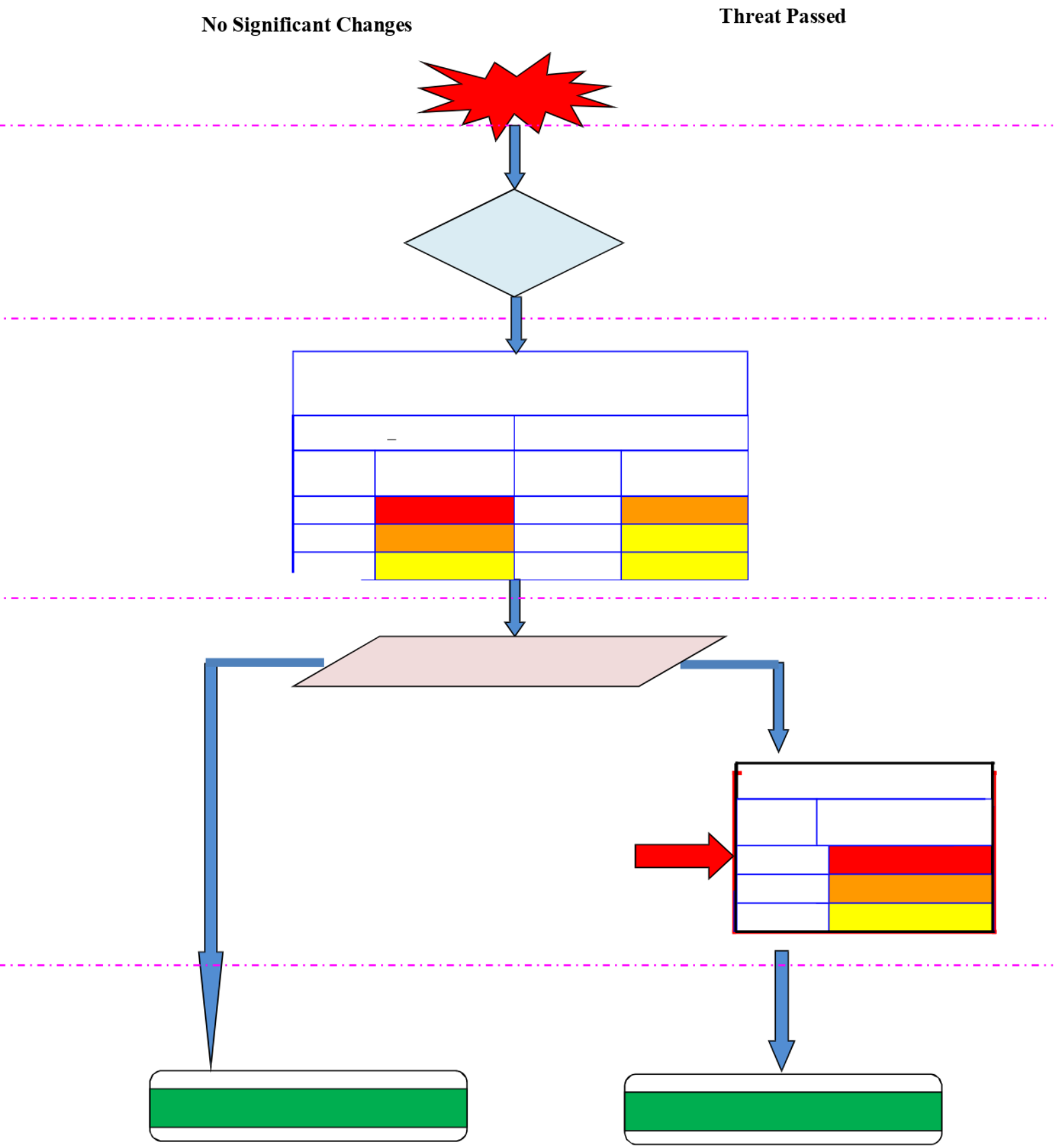
EWA (M)	Threat Status
> 2	WARNING
0.5 to 2	ALERT
0.2 to 0.5	WATCH

Upgraded Threat Status

EWA (M)	Threat Status
> 2	WARNING
0.5 to 2	ALERT
0.2 to 0.5	ALERT

Final/ Threat Passed

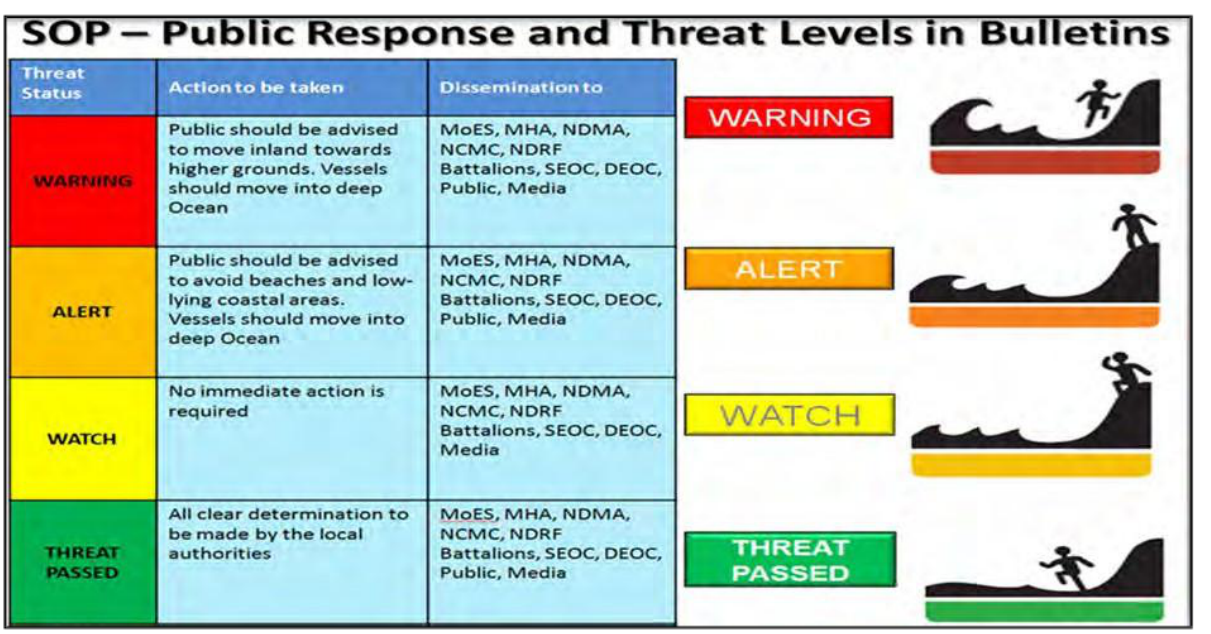
FINAL: No significant change in WL (or) Last exceedance of threat threshold at last Indian Coast + 120 mins


No Significant Changes
Threat Passed

26. The details of Tsunami Bulletin Types are as follows:-

Bulletin type	Information	Time of issue (Earthquake Origin time as T_0) minutes
Type-1	Preliminary EQ Parameters	T_0 + 10
Type-2	No Threat Information from Model Scenarios	T_0 + 20
	Threat (WARNING / ALERT / WATCH) Information from Model Scenarios	
Type-3	Real-time water level observations indicating Tsunami Generation	As and when the first real-time water level observation is available
Type-4 (Final)	No significant tsunami	120 mins after the last exceedance of 0.5 M threat threshold at last Indian Ocean member state
	Threat Passed	

27. The actions to be taken during various threats levels are as follows: -



28. **Standard Operating Procedure (SOP) of Disaster Management Offices- Role of Disaster Management Offices (DMO)**. The Disaster Management Offices (DMOs) should play key role in taking efficient and immediate actions to ensure public safety prior, during, and after the event. DMOs should follow guidelines as highlighted in INCOIS SOP training manual published by INCOIS, MoES.

29. Following are the recommended Roles & Responsibilities for DMOs:-

(a) Identify the hazards and vulnerable communities

(b) Prepare the public for tsunamis, through education and awareness, communication of risk to communities

(c) Receive official science-based tsunami warning messages from the TWC

(d) Ensure information flow from warning centres to the public

(e) Activate local public alert systems as appropriate

(f) Decide and manage evacuations through local Emergency Operations Centres (EOCs)

(g) Communicate "All Clear" when it is safe for the public to return to coastal areas.

***Note** : DMOs SOP for emergency response shall be i.a.w. INCOIS SOP training manual for Tsunami*

30. **DMO's SOP for Emergency Response**. Emergency Response plans and their component SOPs are the documents that form the basis for real-time emergency action. SOPs outline the specific procedures to be followed in case of an emergency. They also serve as the framework for conducting routine drills and exercises to ensure that response procedures can be effectively implemented by 24x7 duty staff. These drills and exercises include stakeholder familiarization workshops, agency and multi-agency drills, table top scenario exercises, and functional communications tests, as well as full-scale response agency field deployment exercises, which may or may not include public evacuations. These documents and drills also ensure the consistency of actions, especially considering the possibility of multiple turnovers of duty staff between actual tsunami events.

31. In order to promote long-term sustainability and development of the national and local elements of the DMOs, they should be capable of: -

(a) Interpret the technical information: including inundation maps, scenarios, and modelling results.

(b) Understand the tsunami warning system and disseminate warning information effectively.

(c) Design warning protocols in simple, local languages easily understandable to the general public.

(d) Develop guidelines for establishing and operating 24x7 local emergency operational centres for receiving tsunami advisories.

(e) Develop emergency plans for areas not covered by inundation maps.

(f) Ensure rapid access to technical advice during a tsunami situation.

(g) Develop guidelines for planning evacuation routes and placing signage.

(h) Establish mechanisms for training new personnel about tsunami issues.

(j) Exchange information with other coastal emergency managers.

(k) Ensure reliability by implementing system redundancy measures.

CHAPTER-7

EMERGENCY TSUNAMI RESPONSE

CHAPTER-7

EMERGENCY TSUNAMI RESPONSE

Tsunami Response Requirement

1. A coordinated and effective response system is essential for managing tsunamis at the Central, State, district, and community levels. Prompt communication and dissemination of warnings to all stakeholders are imperative for an effective response. Upon issuance of the warning, the Tsunami Response Plan will be activated in the affected areas. Response to early warnings will involve the safe evacuation of community populations with minimal loss to property (both living and non-living assets).

2. Depending on the scale of the tsunami, the run-up height, and the level of storm surge, response efforts will be mobilized at the community, district, state, and national levels. Disaster Management Authorities at various levels will institutionalize systems for coordination between various agencies, including Central Government Ministries, Departments, State Governments, district authorities, Urban Local Bodies (ULBs), Panchayati Raj Institutions (PRIs), and other stakeholders, to ensure an effective tsunami response.

Emergency Search and Rescue

3. Past experiences in various disaster situations have demonstrated that the community is often the first responder in all types of disasters. Before the intervention of State machinery and specialized search and rescue teams, local communities respond initially and save numerous lives. Trained and equipped teams comprising local residents will be established along coastal areas to respond effectively in the event of a tsunami. It is crucial to periodically induct freshly trained local youths into these teams to ensure a swift response.

4. Community-level teams will be developed in coastal districts with basic training in search and rescue operations. Training modules for trainers of community-level search and rescue teams will be developed by NDRF training institutes. On the ground, NDRF battalions will assist state governments and district authorities in training communities. They will be further supported by Civil Defence, Home Guards, Fire Services, and NGOs. State governments will establish procedures for formally recognizing and certifying trained search and rescue team members. Suitable indemnity will be provided to community-level team members by state governments for their actions during emergency responses following a tsunami. Youth organizations such as the National Cadet Corps (NCC), National Service Scheme (NSS), and Nehru Yuva Kendra Sangathan (NYKS) will provide support services to response teams at the local level under the overall guidance and supervision of local administration.

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

5. INHD plays a significant role, especially during natural disasters affecting coastal areas. During the devastating Bhuj Earthquake of January 2001, which struck the Gujarat coast in the Gulf of Kutch, two Indian Naval survey ships conducted urgent surveys of the Kandla port channel and their approaches to resume shipping activities in the area. These ships were also converted into hospital ships to provide necessary medical logistical support to earthquake victims and deliver relief measures. During the Indian Ocean Tsunami on December 26th, 2004, seven of the eight survey ships were deployed from Indonesia to Sri Lanka to open basic sea lines of communication, facilitating the smooth flow of international aid. Additionally, helicopters and versatile crews were engaged in providing medical aid. Following the tsunami, these ships urgently re-charted the area and updated bathymetry information for most areas in Andaman and Nicobar. INHD shall also be activated during any future tsunami emergency, utilizing survey ships equipped with boats and integral state-of-the-art response mechanisms.

6. Tsunami response will primarily focus on our coastal districts. All agencies mentioned in Chapter-II of this document, including the Armed Forces, Paramilitary Forces, Marine Police, Department of Fisheries, and other relevant agencies, shall provide aid to civil power in forming disaster response teams. The actions to be undertaken by these agencies are as follows: -

TSUNAMI RESPONSE		
CONTINGENCY ACTIONS (PREPARATION)		
Ser.	**Action**	**Agency**
(a)	Predictive modelling	INCOIS
(b)	Preparation of agency specific SOPs	All concern Agencies
ACTION ON ISSUE OF WARNING		
(c)	Monitoring earthquake, rainfall, flooding to provide drainage path	INCOIS / IMD
(d)	Issue alerts and periodical bulletins	INCOIS / State Govt/ SDMAs
(e)	Issue site specific warning and feed back to MHA	State Relief commissioner/ Secretary DM
(f)	Dissemination of warning in Coastal District and Maritime domain	Ports/ Harbours/ Coast Guard/ Navy/ NHO/ State & UT Administration/ Police/ NGOs/ other public offices/ Department of Fisheries/ All concerned vide chapter-II of this docket

(g)	Mobilisation of sea going assets to safer location	All concerned agencies to initiate action for safeguarding their assets
ACTION DURING TSUNAMI		
(h)	Maritime SAR in coastal areas to be undertaken as per guidelines of NMSAR manual.	All concerned agencies.
ACTION POST TSUNAMI		
(j)	Mobilisation of surface and air assets for SAR post tsunami as there is a danger of personnel /populace getting washed out in receding tsunami waves.	*IN*, ICG, Marine Police, Indian Customs, Fisheries, CISF and all concerned.
All agencies are to execute the instructions in expeditious manner. ***Note- Contact details of key stakeholders are placed at appendix 'B'***		

Appendix 'A'
{Refer to Ch-2 para 1(b)(ii) & Ch-4, Table-Post Cyclone Operators}

STAKEHOLDERS TO UPDATE CONTACT DETAILS OF STAKE HOLDERS AT STATE LEVEL FOR ACTION IN CYCLONE.

Appendix 'B'
(Refer to Chapter 7 para 6)

STAKEHOLDERS TO UPDATE CONTACT DETAILS OF STAKE HOLDERS AT STATE LEVEL FOR ACTION IN TSUNAMI.

Appendix 'C'
{Refers Ch-4, Note of Para 4}

NDMA CYCLONE ADVISORY
PREPARATORY ACTIONS BY SDMA, DDMAS, LOCAL GOVERNING BODIES, EMERGENCY SUPPORT FUNCTION (ESF) ORGANISATIONS & STAKEHOLDERS

Sl. No.	Cyclone Impact Areas & ESFs	Actions by Concerned Stakeholders
1.	Vulnerable urban and rural localities	(a) Identify coastal villages, fishing hamlets, urban localities & low-lying areas which are prone to cyclonic winds, heavy rainfall, waterlogging & flooding. (b) Notify local governing bodies to prepare for evacuation, mass shelter & provision of human services.
2.	Vulnerable creeks, river mouths, coastline	(a) Creeks, river mouths and low-lying coastline areas may face storm surge during cyclone impact and bear significant damage. (b) Shifting of boats, shops, shacks & evacuation of people from houses, workplaces, business areas etc. in such zones, in due time well before cyclone makes land fall and storm surge builds up.
3.	Transport hubs (Bus/ Railways/Airports/Road Transport & Logistics Centres)	(a) Road transport department to identify transport hubs, road infrastructure, bridges, highways which are likely to be disrupted on cyclone impact. (b) PWD & support agencies to mobilize resources to ensure continuity of road connectivity/restoration/repairs in case of damage. Resources include QRTs/ manpower, material & equipment etc.
4.	Hospitals & Primary Health Centres including private hospitals, medical colleges & nursing schools	(a) Protection measures for vulnerable areas of hospitals like ground level wards/labs against flooding, emergency power generation equipment, water supply, doors & windows, pharma & oxygen supply units etc. (b) Mobilisation of additional para-medics,

		medical stores & IAG/Red Cross trained community volunteers for support functions (from non-impact areas). (c) Stocking of essential medicines & equipment. (d) Arrangements for mass triage. (e) Medical & health department briefing at local and district level, planning for delivery of Medical Emergency Support Functions. (f) Mobilisation of ambulance (to be at disposal of local & district administration/incident Commanders). (g) ASHA & Anganwadi workers are to be mobilised in impact areas for assisting evacuation of pregnant women with functional needs. They also form part of support group at Relief Camps.
5.	Industrial Hubs including SEZs. Industrial Parks, Industrial clusters, Chemical Zones, Chemical warehouses	(a) Industry associations and authorities to be apprised of high winds speeds and heavy rains in area. (b) Protection measures to be instituted for vulnerable industries, high rise structures. (c) Shutting down of vulnerable units, evacuation of manpower, and mobilisation of response teams, ambulance to be coordinated at local as well as district administration level. (d) Enhanced fire and medical support to be ensured for cyclone induced industrial disaster incidents. (e) Chemical incident response teams to be organised from within as well as outside resources of industry park/SEZ authorities. (f) Associations may pool resources for emergency response in well planned manner.
6.	Petro-chemical installations including	(a) Coordination with OMCs & PNG stakeholders (IOCL, BPCL, HPCL, GAIL, ONGC,

	storage tank farms, bulk depots, bottling plannts, refineries.	Reliance). (b) Stakeholders must make assessment of vulnerability of large structures/refinery columns/tanks & pipelines to withstand projected cyclonic winds in the area. (c) Vulnerable structures to be taken away from operational use and safety measures to be instituted as per SOP.
7.	Coastal shipping including major and minor ports, SPM operators, shipping agents	(a) All operators of major and minor ports & terminals, SPMs in the cyclone impact area are to be advised to suspend operations, move shipping to safer locations, keep emergency response teams ready for Search & Rescue as well as Oil spill/ chemical, Petro-chemical cargo discharge in their jurisdiction. (b) Liaise with State and District EOCs for update and situational awareness. (c) All labour camps, private and third-party contractors are to be cautioned and take emergency measures for protection of life and property. Loose metal/tin sheets are to be removed; migrants shifted to safer locations etc. (d) All highrise port cranes, mobile equipment and masts are to be secured in sfe zones as per SOP to withstand cyclonic winds and prevent damage. (e) Port Control Towers, warehouses (especially doors, windows, exhaust systems, glass façade) are to be inspected for vulnerability to cyclonic winds, alternate offsite control rooms may be established in case port premises are directly under cyclone impact zone. (f) Bulk cargo especially chemicals, urea, coal to be secured/removed from vulnerable areas. (g) All ships, tugs, vessels on chokes, dry docks, anchorages in port area are to be secured for storm surge. Hurricane Howsers

		are must for berthing inside port area. (h) Port authorities must monitor all meteorology parametres like pressure, wind speed etc. and convey the same to SEOC & DEOC. Situations like sudden drop of pressure to be monitored. (j) Indian Coast Guard and Navy are to pre-position their well-equipped & self-contained Emergency Response Teams under HADR provisions to port areas. (k) Port authorities must convene meeting of all shipping agents for withdrawal of unsafe vessels, non-propelled barges, tugs, oil rigs and platforms within their jurisdiction. (l) Vessels in inner as well outer anchorages to be assessed for bearing cyclone impact and moved to alternate locations. (m) All kinds of coastal shipping activity and marine passenger boats, inland barges are to cease operations. (n) State Maritime Boards to take pre-emptive actions.
8.	School, Colleges & other educational/ professional institutions	(a) School and colleges are to prepared for establishing relief camps and medical aid posts. (b) Accounting of persons sheltered, establishing of community kitchen, emergency power through portable generators. (c) Water bowsers for meeting requirements of drinking/cooking and sanitation etc. are to be arranged. (d) All such relief camps to have an administrative unit for managing logistics & essential services smoothly. (e) Police teams to be deputed for maintaining law and order. (f) NGOs and community groups to be

		involved for all kinds of assistance.
9.	District & State EOCs	(a) EOCs to build a situational awareness picture based on IMD forecast, satellite pictures/images and GIS plot. (b) GIS plot depicting vulnerable localities, hospitals, PHCs, relief camps, power utilities, transport hubs, highways, ports and harbours, lakes and water bodies, pumping stations, schools, and colleges, staging areas etc. are key to decision making and saving lives in the aftermath of cyclone. (c) District level DDMA committees as per NDMA Act 2005 to be activated. (d) Formation of Nodal Group at DDMA & SDMA level including local officers of IMD, Armed Forces, Indian Coast Guard, INCOIS, NDRF, CRPF & other central resource & response agencies.
10.	Fire Services, SDRF, Home Guards, Appada Mitras	(a) Department of fire services, SDRF to keep resources ready for emergency search and rescue operations in staging areas near vulnerable areas/localities. (b) Additional resources from non-cyclone impact areas are to be mobilised for duration of emergency response. (c) Services of Appada Mitras & IAG/Red Cross trained volunteers to be utilised in Relief Camps, Control Rooms, Hospitals etc.
11.	Telecom Operators	(a) All Telecom Operators (private and BSNL) to be impressed upon to constitute emergency response teams for quick restoration of damaged telecom infra if hit by cyclone. (b) If feasible, mobile telecom towers for mobile connectivity in disaster zone may be kept standby.
12.	Power sub-stations & distribution nodes	(a) All power sub-stations especially in coastal areas, low lying areas are to institute

		flood protection measures like flood proofing. (b) Carry out vulnerability assessment and take actions for damage control.
13.	Pharma & Chemical Industry	(a) Industries maintaining stock of hazardous & noxious substances, chemicals & explosives which may pose threat to public health and safety to be told to institute safeguards and protection measures. (b) Shift stock from unsafe/vulnerable locations. (c) Storage tanks & warehouses are to be inspected for potential damage. (d) Stock holding of and raw materials/products to be reduced to safe limits for safety of local population and area.
14.	Food & water supply department	(a) Food & Supply department to plan for maintaining supplies at Relief Camps, cyclone impact coastal and remote localities. (b) Adequate arrangements to be made for air dropping of large no. of food packets. (c) Response forces are to be ready for supply of food packets rations, water to flooded localities, people stranded on roof tops etc. (d) Focus required on adequate number of suitable delivery vehicles & manpower to maintain supply to relief camps and affected areas. (e) Water supply department to ensure availability of generators for water pumping stations in affected areas. (f) Provision for food for infants, pregnant ladies & old, sick people to made at Relief Camps.
15.	NGOs, Community Groups & Associations	Mobilisations of NGOs, Community Groups including faith-based organisations as per their

		area of expertise and resource availability to be deployed through district administration and EOCs.
16.	Community Awareness & Alerts	(a) Vulnerable communities are to reached out through multiple means like onsite announcements, messages through TV channels, radios, community/gram panchayat public announcement system and CAP alert messages and coastal sirens. (b) Involvement of Community as first responders through community leaders and local administration is important in the golden hour of emergency response. (c) Pre-planning, coordination meetings to be organised in vulnerable areas, safety measures to be discussed. (d) High risk operations to be undertaken only by response forces.
17.	Fishing Community	(a) Fishing community to be assisted in securing their boats & equipment on land/on chokes especially in port and harbours, creeks and river mouths which are in direct line of cyclone movement. (b) Fishing community is to be apprised of storm surge warning. (c) Fishing association to ensure "no fishermen, boat/ferry venture out into the sea" from boat operating centres, fishing harbours during cyclone warning phase.
18.	Activation of Incident Response System (IRS) Organisation in Cyclone Impact Areas	(a) Most importantly all response activities as mentioned above are to be executed through IRS **Unified Command**. (b) Activation of Incident Response System in early phase of disaster warning is crucial for saving life and property. (c) SEOC & DEOC to play crucial role in establishing an effective IRS response setup.

19.	Utilisation of resources of Armed Forces	(a) Army, Navy, Airforce & Indian Coast Guard to be part of Unified Command at State (as well as District level in impact zone). (b) Armed Forces (assisted by SDMA/DDMAs) are to identify helipads for air operations and deploy air assets. Resources of local airports/AAI to be utilised for air operations also. (c) During cyclone induced disasters in industrial zones, the CBRN/NBCD teams of Armed Forces (especially of Indian Navy at Vishakhapatnam, Chennai, Kolkata) to be alerted for handling leaks/discharges. (d) Resources & expertise of Oil Spill Pollution Response Teams (PRTs) of Coast Guard to be utilised as appropriate in early stages of such secondary disasters.