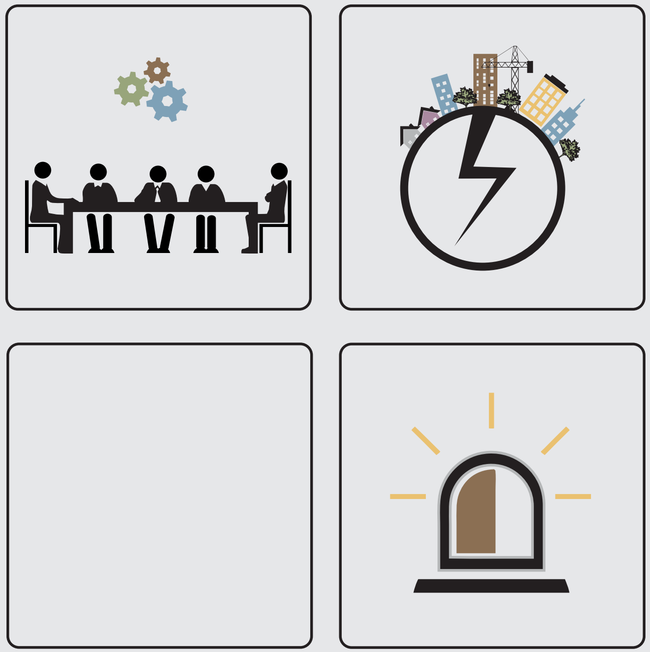
REVIEW OF EARLY WARNING SYSTEM

CUTTACK CITY



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ACKNOWLEDGEMENTS

This work was conducted under the USAID-GoI-UNDP Partnership Project on ‘Developing Resilient Cities through Risk Reduction in the context of Disaster and Climate Change’ and Dharamshala City under the RBAP funds for Dharamshala Smart City Limited (DSCL).

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The review process involved a number of consultation meetings and a workshop in the city. The support of the city government, state and central government departments/ institutions is highly appreciated. Specifically, we would like to highlight the support and in-depth engagement of Smt. Sarita Dhanwar, Deputy Commisioner and Mr. P.K. Mohanty and City Project Officer (CPO) from CMC.

A word of special thanks to United Nations Development Programme (India) for their fruitful partnership throughout the implementation of the review process, for their valuable support in coordinating the activities as well as in organizing city missions, and for stakeholder consultations and city workshops.

The findings of the review have been shared and reviewed by the key stakeholders, including the Local Government and their valuable inputs have been incorporated in the final report.

The report takes into account the End-to-End Early Warning System approach of the Regional Integrated Multi-Hazard Early Warning System. This report has been prepared by a six member team with experience in areas of disaster risk management, the hazard risk assessment, early warning system design and climate risk management.

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EXECUTIVE SUMMARY

India is highly diverse in terms of geography and climate and so are its cities. Cities are exposed to earthquakes, tsunamis, landslides, heavy precipitation, floods, heat waves, cyclone and severe winds, public health risks among others. Past disasters have shown significant impact on city economy and on key sectors (such as transport, energy, water and sanitation, trade and commerce). It is expected that due to climate variability and climate change, the frequency and intensity of the hydro-meteorological hazards will see an increase in future. This, combined with poor reservoir management practices, especially in cities located downstream the reservoirs, may put the lives of citizens and city assets at risk.

This situation leads to advancements in observation and monitoring, mathematical modelling, computing capabilities, communication technology and conduct of scientific risk assessment have allowed technical and disaster management agencies to disseminate timely and accurate warnings and move people and assets from the harm's way. One example of this is the case of Cyclone Phailin, where accurate forecast was made by the Indian Meteorological Department (Cyclone Warning Division) and timely dissemination of warnings to at-risk communities was done by the Orissa State and the District Agencies. Another example is the case of public health. Systemic collection of registered cases and observation of diseases in the city of Surat have led to the provision of timely information on potential outbreaks. Advance information on potential outbreaks leads to identification of additional measures to be stepped up by the local government to reduce the risk of diseases such as malaria, dengue, cholera, filariasis, among others.

This review is commissioned by UNDP under Contract (2016/232), and is an initiative under USAID-GoI-UNDP Partnership Project on 'Developing Resilient Cities through Risk Reduction in the context of Disaster and Climate Change' and Dharamshala City under the RBAP funds for Dharamshala Smart City Limited (DSCL).

The review investigates the condition of EWS governance, requirements of EWS users, core services provided by technical and disaster management agencies, coordination mechanism between technical and disaster management agencies and finally the issues centred on service delivery and feedback in three cities (Cuttack, Dharamshala and Shillong). The report provides firsthand guidance as well as the steps for development of EWS from the city level to the urban local body (ULB), disaster management institutions, technical agencies involved in design and implementation of early warning systems for geological hazards, hydro-meteorological hazards and public health risks.

Methodology of Review

The assessment for three cities (Cuttack, Dharamshala and Shillong) involved a systematic flow of understanding the EWS governance at the national, state, district and city levels; institutional mechanism and their roles within the elements of EWS; delivery of products and services by technical and disaster management agencies, as well as their coordination mechanism/ operational cooperation; reviewing the existing EWS mechanism in cities; role of agencies in EWS and their integration in the disaster management institutional framework (City Disaster Management Plan); discussing with stakeholders the needs in EWS and gaps thereof, capacities of institutions (technical agencies) engaged in EWS, the operational cooperation of technical agencies with the emergency departments/functionaries at the district and city levels (emergency management structure and response capabilities), current status and future needs of observation and monitoring capabilities, data management systems; seeking information on pre-computed assessment of risks for various intensity of hazards (risk assessment), hazard analysis and prediction capabilities (threat assessment/potential impact assessment), warning formulation/issuing of guidance and potential outlook/provision of actionable early warning information/warning products, decision making, generation of tailored risk information and dissemination of risk information to at-risk communities or hot-spot locations (risk communication), information technology and telecommunication capabilities, preparation of response options, institution/emergency responders and community response.

The assessment was based on the information obtained through a set of processes.

- Design of the review framework by the Review Team,
- A checklist and questionnaire prepared by the Review Team for obtaining information from technical and disaster management agencies,
- Mission to select cities to understand the EWS environment,
- Development of Criteria Development Matrix taking into consideration all the key elements of end-to-end EWS,
- Information collected through stakeholder consultations/meetings, workshops in respective cities, discussions with programme focal point in cities, meeting with key experts,

- Exchange and mid-term feedback from UNDP programme team,
- Development of policy brief, where key recommendations cited are discussed for endorsement at the policy level,
- Workshop with city stakeholders, sharing of results,
- Final report and presentation.

Key Observations and Recommendations

Based on the development stage indicators for all the six components (1. EWS governance – national, state and city level institutional framework, 2. User needs, 3. Operational components of EWS, 4. Products and services across the warning chain, 5. Coordination mechanism, 6. Service delivery and feedback loops), the report provides the summary for each city highlighting the current status. The Criteria Development Matrix (CDM) also outlines the reason for selecting the development stage indicators. Specific recommendations are presented together and this will lead to the development of policy brief. The overall analysis of this review revealed that in Cuttack city:

- EWS development is crucial for sustainable development and building resilience of the city. It is therefore important to develop an EWS framework and strengthen strategies across all levels to ensure better coordination efforts for functional EWS at the city level. This must be seen as opportunity to strengthen network among institutions, foster partnerships and build the capacities of all keys stakeholders.
- EWS framework must be made as a functional component of the DM Plan process (national/state/district/city). The framework must foster areas of cooperation in data sharing and impact forecasting.
- It is widely realized that city institutions are being rather response-centric instead of being the ones that take preventive measures. The technical capacity in understanding DRR, risk assessment and EWS needs to be strengthened at the ULB level. City level hazard and vulnerability mapping capabilities need to be enhanced on priority basis. During review, City level Hazard Risk and Vulnerability Assessment (HRVA) was in process for Cuttack city. A long-term perspective on capacity development should be envisaged.
- There is a common challenge in the interpretation of the forecast products with is provided by technical agencies such as IMD. Technical agencies involved in providing warning have to evolve in providing information that can either be used by a wide pool of users or create products based on user needs.
- Technical agencies/scientific institutions must also enhance the capability to deliver timely warnings with sufficient respite time so that they support DRR functions at the city level.
- The role of technical agencies in warning formulation is increasingly being recognized. It is therefore important to strengthen institutional coordination mechanism between technical and disaster management agencies at all levels.
- City government/ULB has to make significant investments towards development of EWS and associated mechanisms such as a functional EOC. The current level of preparedness and resource allocation is not sufficient to kick-start any activity around EWS.

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ABBREVIATIONS

ACWC Area Cyclone Warning Centre
BSNL Bhart Sanchar Nigam Limited
CBO Community Based Organization
CDM Criteria Development Matrix
CDMO Chief District Medical Officer
CDP City Development Plan
CDPO Child Development Project Officer
CESU Central Electricity Supply Utility
CFO Chief Fire Officer
CMC Cuttack Municipal Corporation
CWC Central Water Commission
DDMA District Disaster Management Authority
DM Disaster Management
DRR Disaster Risk Reduction
EOC Emergency Operation Centre
ESF Emergency Support Function
EWS Early Warning System
GIS Geographical Information Systems
GOI Government of India
GSI Geological Survey of India
IC Incident Commander
IDSP Integrated Disease Surveillance Programme
IMD India Meteorological Department
IRS Incident Response System
IT Information Technology
M&E Monitoring and Evaluation
MHA Ministry of Home Affairs
OSDMA Odisha State Disaster Management Authority
HRVA Hazard Risk and Vulnerability Assessment
MSK Medvedev-Sponheuer–Karnik Intensity Scale
NDMA National Disaster Management Authority
NGO Non-Governmental Organization
PAS Public Addressal System
WRD Water Resource Department
RFP Request for Proposal
RIMES Regional Integrated Multi-Hazard Early Warning System for Africa and Asia
RSMC Regional Specialized Meteorological Centre
RTSMN Real Time Seismic Monitoring Network
SEOC State Emergency Operations Center
SMS Short Messaging Service
SOP Standard Operating Procedures
SRC State Resource Center
ULB Urban Local Body
UNDP United Nations Development Programme
USAID United States Agency for International Development

GLOSSARY

Capacity
The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals

Climate change
The Inter-governmental Panel on Climate Change (IPCC) defines climate change as: “a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use”

Disaster
A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources

Disaster risk reduction
The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events

Early warning system
The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss

Forecast
Definite statement or statistical estimate of the likely occurrence of a future event or conditions for a specific area

Geological hazard
Geological process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage

Hazard
A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage

Hydro-meteorological hazard
Process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage

Natural hazard
Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage

Preparedness
The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions

Prevention
The outright avoidance of adverse impacts of hazards and related disasters

Response
The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected

Risk
The combination of the probability of an event and its negative consequences

Risk assessment
A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend

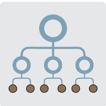
Risk management
The systematic approach and practice of managing uncertainty to minimize potential harm and loss

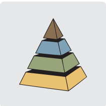
Vulnerability
The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard

Source: 2009, UNISDR Terminology on Disaster Risk Reduction

LIST OF ICONS


Background informartion on Review of EWS in 3 cities in India under the ongoing intitatve of Climate Risk Management in Urban Areas through Disaster Preparedness and Mitigation project by UNDP.

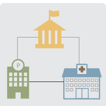

Methodology/Systematic approach adopted to assess the existing EWS and emergency communication netwrok in 3 cities across India.


The Criteria Development Matrix indicates the possibility of thinking 5 stages of development and helps to review each criterion built around 6 components of the development model of EWS.


General city information like location, climate, demographics, landuse, administration, etc. helps to understand the city and its development of Disaster Management Plan.


Hazard Risk like geo-physical, hydro-meteorological and public health are studied for each city, which would help in reviewing of EWS and later in development of Disaster Management Plan.


The city and its infrastructure are vulnerable to incidences of both geo-physical & hydro-meteorological events. Such event is likely to affect the livellhood of population in addition to economic loss.


Study of Institutional Framework for a city helps to understand the coordination mechanism among various stakeholders, during the time of disaster.

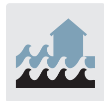

Summary of all the criteria of all 6 components of study framework and discussed in brief.

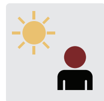

Earthquake

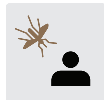

Tsunami


Landslide


Cyclone


Flood

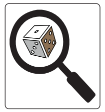

Heatwave

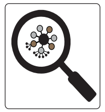

Public health risk


Observation and Monitoring


Data Analysis

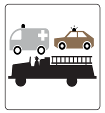

Prediction


Risk Assessment


Potential Impact Assessment


Warning Formulation


Dissemination to communities at risk


Preparation of Response


Community Response

1. INTRODUCTION

Sendai Framework for Disaster Risk Reduction, 2015-2030 (Sendai Framework is the successor instrument to the Hyogo Framework for Action, 2005-2015: Building the Resilience of Nations and Communities to Disasters) has also led to a paradigm shift in disaster risk management from a post-disaster response to a comprehensive and strategic approach in disaster risk management encompassing preparedness and prevention strategies. It aims for the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. The seventh goal (g) of Sendai framework stresses substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030.

Hazards of different origin and intensity have caused significant loss of lives and economic damages in past few years. The damages are showing a growing trend, and increase in climate variability and climate change can tip of many existing mechanisms of managing risk. A closer look into the nature of the hazard events clearly indicates the role of the technical agencies (national/regional/state/city) and the disaster management agencies (at the national/state/district/city/village) in early warning as critical. The increasing factor of risk in today's society underlines the need for enhanced cooperation from a wide spectrum of stakeholders in effective risk reduction and emergency response.

At country level, there is a growing reliance upon EWS as more people and assets are being exposed to the hazards. This calls for functional EWS (most effective for events that take time to normally develop, such as tropical cyclone) or Alert Systems (most effective for events that start immediately, such as earthquake) that have applicability for most hazards. In 2013, Government of Orissa agencies evacuated more than half million people in advance of tropical cyclone (Phailin, Category: Very Severe Cyclonic Storm) thereby reducing fatalities to a fraction (loss of human life - 21) when compared to the fatalities (loss of human life - 9887) from a tropical cyclone (Paradip Cyclone, Category: Super Cyclonic Storm) in the same region 14 years previously.

This study is a review of existing Early Warning Sytem in the city and not hazard, vulnerability and risk assessment (HVRA).

Early Warning Systems (EWS) are well recognized as a critical life-saving tool for Hydro-meteorological Hazard (such as Floods, Cyclone, Droughts), and other hazards as well. According to WMO, the recorded economic losses linked to extreme hydro-meteorological events have increased nearly 50 times over the past five decades, but the global loss of life has decreased significantly, by a factor of about 10, thus saving millions of lives over this period. This has been attributed to better monitoring and forecasting of hydro-meteorological hazards and more effective emergency preparedness. A systematic approach towards managing risk through an established early warning system (EWS) can minimize loss of lives and adverse economic impact. EWS backed with effective institutional arrangements can predict hazards in a timely and effective manner, thereby empowering decision makers and communities at risk.

Advancement in observation and monitoring, mathematical modelling, computing capabilities, communication technology and conduct of scientific risk assessment have allowed technical and disaster management agencies to timely disseminate accurate warnings and move people and assets from the harm's way. In the case of Cyclone Phailin, accurate forecast by the Indian Meteorological Department (Cyclone Warning Division) and timely dissemination of warnings to at-risk communities by the Orissa State and the District Agencies made this possible.

The other example is in the case of Public Health, such as systemic collection of registered cases and observations of diseases in the city of Surat has led to the provision of timely information regarding potential outbreaks. Advance information of potential outbreaks leads to identification of additional measures to be stepped up by the local government to reduce the risk of diseases such as malaria, dengue, cholera, filariasis, among others.

Warning dissemination and staging response actions are as important as accurate forecasting and determining potential impact. Any weak link in the elements of EWS (even in case of previous well performing system) will result in under-performance or its failure. Hence evaluation of EWS is important. The evaluation of the system effectiveness can be done during the event, post-event or during the lean period. This review of EWS for all the three cities is done during the lean period. In most cases the cities haven't formally put in place a functional EWS. While it is important to have technical competence around a range of elements (forecasting, prediction, impact assessment), discussions with stakeholders emphasize that EWS is more organizational and institutional process which works to reduce loss.

The methodology adopted in the study has roots to EWS elements defined by RIMES (2008) and the criteria-development concept by Parker (1999).

The review investigates into the condition of EWS governance, requirements of EWS users, core services provided by technical and disaster management agencies, coordination mechanism between technical and disaster management agencies and finally on issues centered around service delivery and feedback.

The purpose of this report is to provide guidance to the city government, disaster management institutions and technical agencies involved in design and implementation of early warning systems for geological hazards, hydro-meteorological hazards & public health risks. This study aims to assess the existing EWS in three cities (Refer Figure 1) through:

- Review of the technical design/structure and efficacy of existing early warning system, assessment of early warning agencies, communications networks, protocols for issue of warning, and transmission to the people, assessment of how the residents of the city access the information and how they act upon it.
- Review of the technologies involved in the early warning system network design, technical specifications, up-time performance standards, connectivity and integration with all the important facilities and installations, emergency services, and the disaster management system in the city.
- Review of the mode of collecting information related to hazard events, monitoring, and transmitting it to other agencies, particularly the municipal government and district

Figure 1: Cities selected for review of EWS 2013-14 and 2016-17

administration.

- Review of the mode and reach of the warning especially last mile connectivity and dissemination plan through mass media, print and audio-visual.
- Review the messages disseminated through the EWS: on timeliness, appropriateness, accuracy, and simplicity parameters.
- Review of the service support for maintaining the EWS on a regular basis and ensuring hundred percent uptime.

This report reviews the institutional mechanism and the decision making across the development model of EWS and its components. This report considers the use of Criteria Development Matrix (tool for review) to assess the level of development and present the findings for three urban centres. Specifically, it focuses on the geological hazard, hydro-meteorological hazard and public health risk warning system, their current status, and capabilities and supporting disaster risk reduction.

Hazards specific EWS options for individual city are presented at the end of the city review sections for ready reference.

Background

Early warning in the usual context means some form of, either written or verbal indication of, an impending hazard. Early warning in the disaster context implies the means by which a potential danger is detected or forecast and an alert issued. In this report, the following definition has been taken into consideration: ‘The provision of timely and effective information, through identifying institutions, that allows individuals exposed to the hazard to take action to avoid or reduce their risk and prepare for an effective response.’ ISDR 2004.

Over the last decade, India has incorporated disaster-reduction policies in its national, social and economic development plans to establish effective preparedness measures and improve the response capacities. The value of timely and effective warnings in averting losses and protecting resources/development assets becomes apparent. Urban centres are exposed to greater risk due to severe exposure of elements at risk (Mumbai Floods 2005, Surat Floods 2006). Some of the recent events show the rising trend in the number of people being affected by disasters, especially in the urban areas.

Warning represents an added value and function in the overall disaster risk management/disaster risk reduction framework. There are three main abilities that constitute the basis of early warning.

- The first is technical capability to identify a potential risk or the likelihood of occurrence of a hazardous phenomenon, which threatens a vulnerable population.
- The second ability is that of identifying accurately the vulnerability of a population to whom a warning has to be directed,
- The third ability, which requires considerable social and cultural awareness, is the communication of information to specific recipients about the threat in sufficient time and with sufficient clarity so that they can take action to avert negative consequences.

Warning systems are only as good as their weakest link. They can, and frequently do, fail in

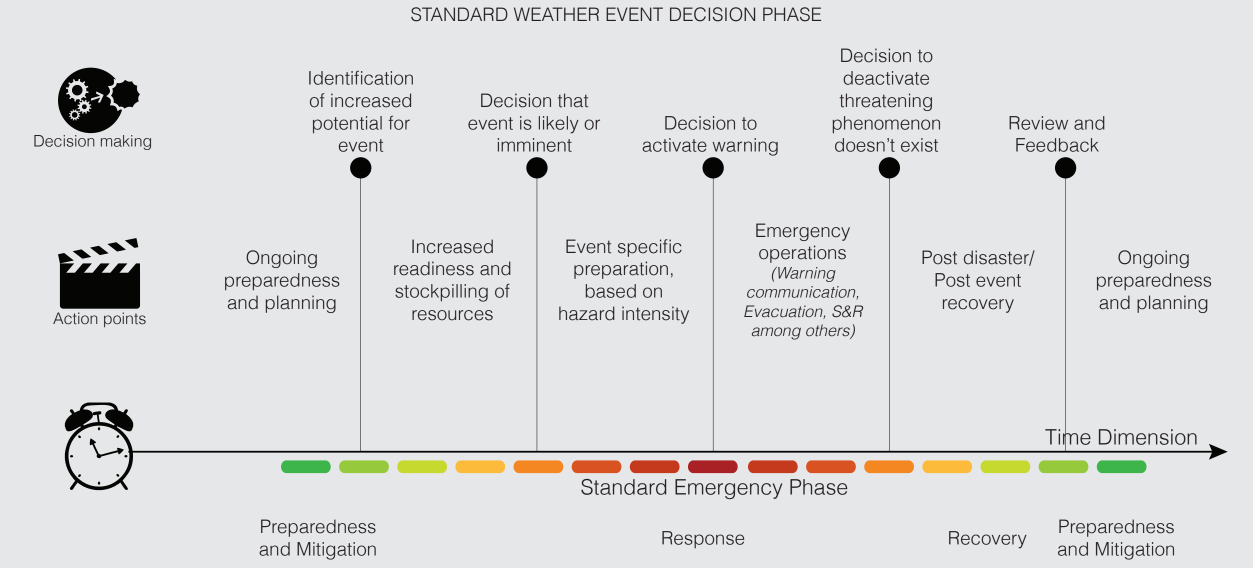


Figure 2: Highlighting overlay of decision points over standard emergency phase and the weather event decision phase

both developing and developed countries for a range of reasons. There are significant decision points for the scientific/technical agencies and the disaster management agencies. These decision points coincide with the phases of the disaster management/emergency management decision stages as shown in Figure 2 (Hydro-meteorological event with sufficient lead time). A range of factors influence the hazard event phase and the emergency phase. They include:

- Lack of standardized EWS framework, which is understood by both technical and disaster management agencies.
- Non-availability of warning information products and services at different temporal and spatial scales, and provision of same information content for various sectors/ stakeholders.
- Warning message not being aligned in terms of societal impacts, risk assessment not being undertaken and potential impact assessment being based on either individual understanding or on past experience and being non-scientific.
- Lack of systemization steps for emergency response based on event severity.
- Warning content unable to facilitate appropriate and timely decision actions at least to those people who are most immediately at risk or are under the influence of the hazard.

An effective early warning system links technical agencies that generate warning information with disaster management/emergency management institutions and finally with communities/people at risk. The end-to-end early warning system (RIMES, 2008) involves the following elements (Figure 3 shows the link between these elements):

1. Observation and monitoring

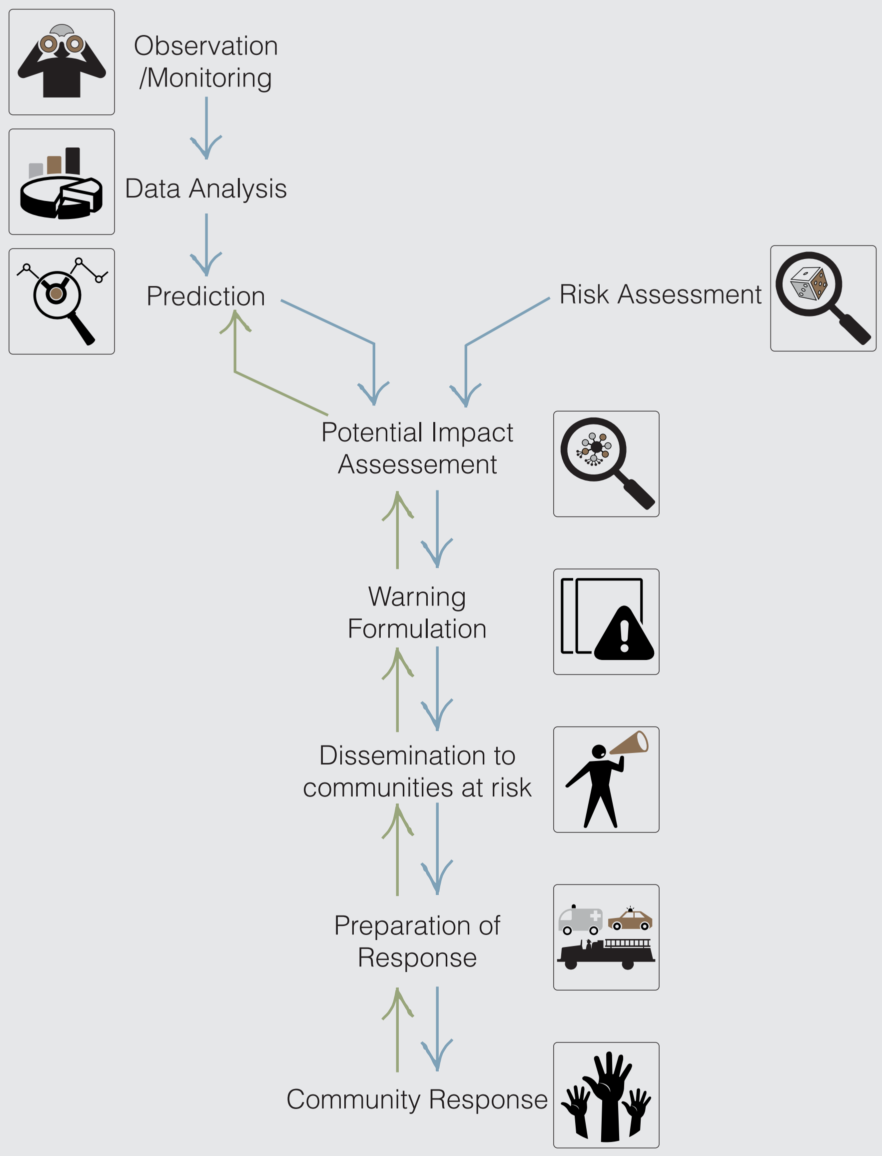


Figure 3: Key elements in end-to-end EWS

2. Data processing and analysis
3. Prediction and forecasting
4. Risk assessment
5. Potential impact assessment
6. Warning formulation
7. Dissemination to communities at risk (until the last mile)
8. Preparation of response options
9. Community response, which is shaped by:
    a. Resourced and practiced emergency response plans
    b. Risk awareness
    c. Mitigation programmes
10. Receiving user feedback
11. System adjustment/improvement

2. METHODOLOGY OF REVIEW

A systematic process was adopted by the Review A systematic process was adopted by the Review Team to assess the EWS, particularly with respect to the systems for geological, hydro-meteorological and public health risks in all the three cities.

The assessment involved a systematic flow of understanding the EWS governance at the national, state, district and city levels; institutional mechanism and their roles within the elements of EWS, delivery of products and services by technical and disaster management agencies, as well as their coordination mechanism/operational cooperation; reviewing of existing mechanism of EWS in cities; role of agencies in EWS and their integration in the disaster management institutional framework (City Disaster Management Plan); discussing with stakeholders the gaps and needs in the EWS, capacities of institutions (technical agencies) engaged in EWS, operational cooperation of technical agencies with the emergency departments/functionaries at the district and city levels (emergency management structure and response capabilities), current status and future needs of observation and monitoring capabilities, data management systems; seeking information on pre-computed assessment of risks for various intensity of hazards (risk assessment), hazard analysis and prediction capabilities (threat assessment/potential impact assessment), warning formulation/issuing of guidance and potential outlook/provision of actionable early warning information/warning products, decision making, generation of tailored risk information and dissemination of risk information to at-risk communities or hot-spot locations (risk communication), information technology and telecommunication capabilities, preparation of response options, institution/emergency responders and community response.

The assessment was based on the information obtained through a set of processes. They are as follows:

- Design of the review framework by the Review Team
- A checklist and questionnaire prepared by the Review Team for obtaining information from technical and disaster management agencies
- Mission to select cities to understand the EWS environment
- Development of Criteria Development Matrix taking into consideration all the key elements of End-to-End EWS (Figure 3)
- Information collected through stakeholder consultations/meetings, workshops in respective cities, discussions with programme focal point in cities, meeting with key experts
- Exchange and mid-term feedback from UNDP programme team
- Development of Policy Brief, where key recommendations cited are discussed for endorsement at the policy level
- Workshop with city stakeholders, sharing of results
- Final report and presentation

The review includes key criteria as indicated in RFP for following key components:

1. TECHINCAL DESIGN / STRUCTURE AND EFFICACY OF EXISTING EWS: Assessment of early warning agencies, communication networks, protocols for issue of warning and transmission to the people. The review should also assess how the residents of the city access the information and how they act upon it.
2. TECHNOLOGIES INVOLVED IN EWS: Review the network design, technical specifications, up-time performance standards, connectivity and integration with all the important facilities and installations, emergency services, and the DM system in the city.
3. MODE OF COLLECTING HAZARD RELATED INFORMATION (Geological hazards, hydrometeorological hazards and disease risks): Review the mode of collecting information related to hazard events, monitoring, and transmitting it to other agencies, particularly the municipal government and district administration.
4. WARNING OUTREACH AND LAST MILE CONNECTIVITY: Review the mode and reach of the warning especially last mile connectivity and dissemination plan through mass media, print and audio-visual medium.
5. MESSAGE CONTENT AND APPROPRIATENESS: Review the messages disseminated through the EWS: on timeliness, appropriateness, accuracy, and simplicity parameters.
6. SERVICE SUPPORT AND SYSTEM MAINTENANCE: Review the service support for maintaining the EWS on a regular basis and ensuring 100 percent uptime.

The schematic diagram (Figure 4) is an illustration of institutional mechanism and decision making around the key warning chain elements. Numbers 1 to 6 in the schematic highlight the core components for evaluating the warning system provided by the technical agencies (national/state/city) to the DM agencies and other DRR stakeholders. The description of the core components and the evaluation principles are summarized below:

1. EWS GOVERNANCE: National, State and City Level Institutional Framework: EWS is underpinned by ministry/department/technical institutions providing operational nowcast/forecasts, products and services to a wide range of users/community. EWS in India is underpinned by legislation (DM Act 2005, State Disaster Management Act, State Disaster Management Policy) and institutional framework that clearly define the roles and responsibilities of various stakeholders among the key warning chain elements. Emphasis under this component was given towards understanding of the organizational coordination and cooperation mechanism (decision making and feedback across key warning elements), and allocation of resources at the city level (functional EOC, risk assessment, human resource capacity).

2. USER NEEDS: The users in the city are spread across government agencies (district DM authority, city DM authority/local authority, emergency services, first responders); communities at risk; general public; NGOs/CBOs; urban service providers (government and private: line departments such as water supply, storm water drainage, drainage, sanitation, health, transportation, energy, law and order); various sectors of the economy including business establishments, trade and commerce; and the media. The requirements and needs of EWS products and services vary among different users.

3. OPERATIONAL COMPONENTS OF EWS: The tasks of the technical agencies and disaster management agencies include developing products and offering a range of services across the warning chain elements. Observation, monitoring, prediction analysis and operational forecasting are core capacities to be exhibited by the technical agencies. The technical agencies rely on a range of supporting functions such as data gathering, data analysis, IT and telecommunication services and product development through qualified and trained staff. The prediction/operational forecast of hazard onset and hazard intensity are to be further translated into the potential impact assessment at the city level and the surrounding regions. In case of the city having a reservoir/dam located upstream, regional forecast needs to further take into account the opening of the reservoir gates and subsequent inundation scenarios for emergency release.

Risk assessment, risk communication and preparedness for emergency response/evacuation are the responsibilities of the local government/DM stakeholders (as identified in the City DM Plan). Guidelines and procedures typically follow the Standard Operating Procedure (SOP) as outlined in the City DM Plan. A sufficient number of qualified and trained staff undertakes the response functions through designated Emergency Support Functions (ESF). The nerve centre of operations during emergency is the City Emergency Operation Centre (EOC equipped with tools for decision support), which functions as the main hub for all emergency functions during the onset of hazard and during the impact, and shall remain operational until the threat phenomenon subsides. Organizational coordination and cooperation mechanism between ESFs are essential for effective delivery of early warning produced/generated by technical agencies.

City-level product development includes outputs derived from risk assessment studies, tailored risk information generated for the event, relevant information technology and telecommunication services for outreach and capability to handle emergency response.

4. PRODUCTS AND SERVICES ACROSS THE WARNING CHAIN: A wide range of products and services aid in decision making. While technical agencies undertake hazard monitoring, detection, analysis, prediction and forecasting (issue advisories to key stakeholders for initiating decisions), risk information will have to be tailored to the requirements of the city and communities at risk.

5. COORDINATION MECHANISM: A large number of institutions are involved in the warning chain elements. Each institution plays an essential role and there is a need for synergy and collaboration between forecasting (warning, data exchange through hydro-meteorological services, climate services, public health etc.) and DM agencies. It is important to analyse if there are any specific provisions of expertise by the technical agencies to the DM stakeholders that could support or enhance decision making.

6. SERVICE DELIVERY AND FEEDBACK LOOPS: While technical agencies issue the forecast and related warning, DM agencies have to understand the user needs and ensure effective and timely delivery of the services (overarching capacities in quality management system is essential for service delivery across functions). Feedback mechanism across the warning element chain helps in improving delivery/quality of product and services over time.

The elements of EWS and components have been integrated into the development of Criteria Development Matrix (CDM).

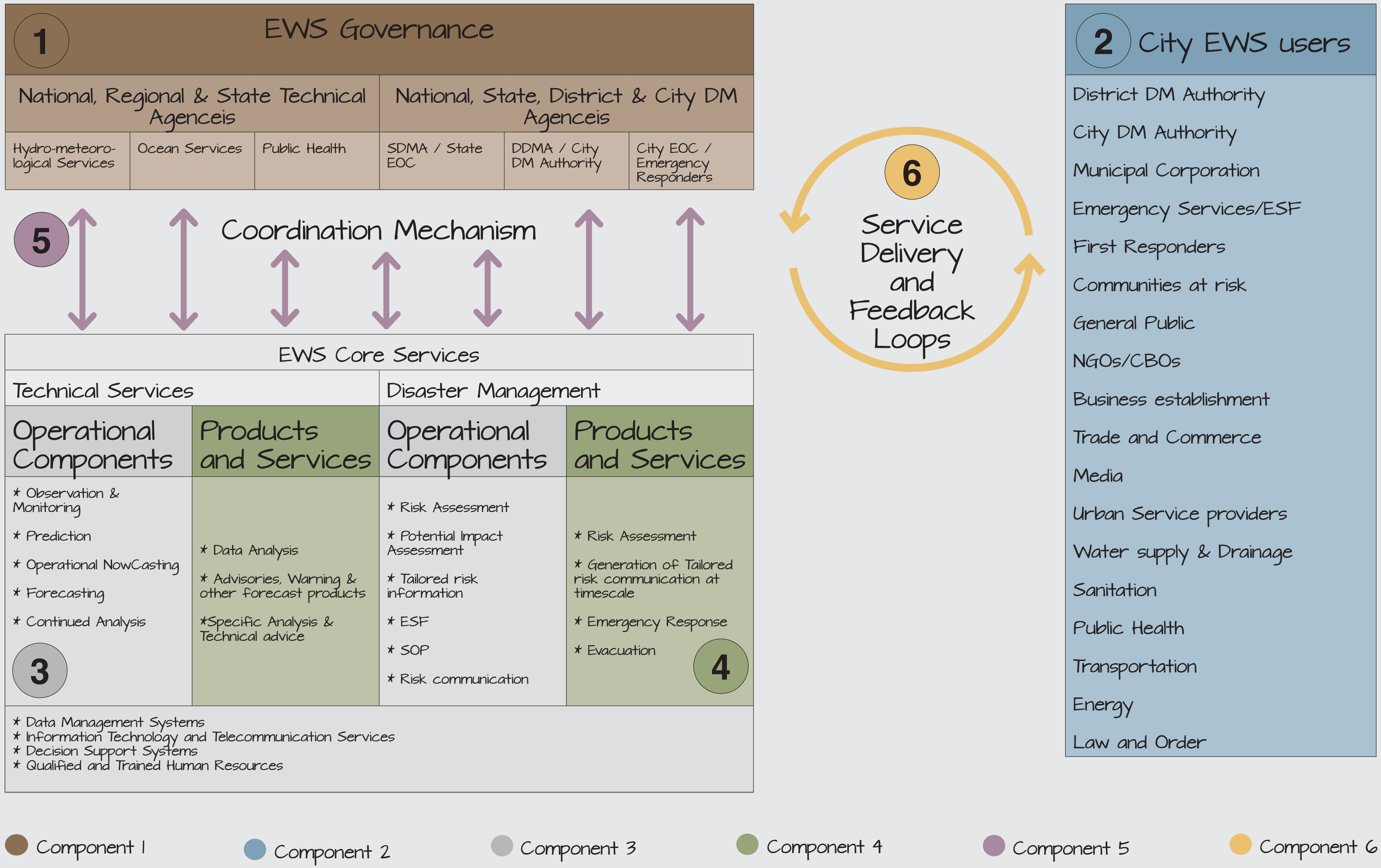


Figure 4: Study framework schematic showing the links of stakeholders across the development model of EWS

Note:Various components analysed are numbered (as in the text) in the schematic

3. CRITERIA DEVELOPMENT MATRIX AND DEVELOPMENT STAGE INDICATORS FOR EWS

The review of EWS employs a range of criteria across six components and subsequent assessment to arrive at the level of development. Based on the past research and studies, the study has adopted the Criteria Development Matrix to review EWS in three cities. The Criteria Development Matrix indicates the possibility of considering five stages of development for each criterion built around the six components of the development model of EWS. The Criteria Development Matrix will indicate the progress as basic (Stage 1 development, which is characterized as rudimentary) to the most advanced (Stage 5 development, which is characterized as current state-of-art and is judged to have reached the fully developed stage containing no major shortcomings). Stages 2, 3 and 4 are characterized as intermediate stages of development. Each of the disaster warnings (hydro-meteorological services, ocean services, climate services and public health services) will be assessed against each criterion and each development stage shall produce a profile indicating the overall stage of development (thereby highlighting gaps and perspective paths for improvement). The level of development stage is based on existing conditions and this can be modified based on the signs of improvement towards a robust EWS at the city level. Subsequent criteria may be added on in further studies or comprehensive EWS audit exercise.

Criteria Development Matrix has been developed through several rounds of discussions by the review team and is in close alignment to the context of EWS development in India. Table 1 highlights six components identified for the review. It defines 35 criteria and details the development stage for each of the criteria. In the review for each city, specific comments/remarks are highlighted for selection of the development stage for each criterion. An overall score indicates the performance of EWS in the city.

Table 1: Criteria development matrix: Criteria and indicators of the condition of ews in cities

S. NO.	COMPONENT 1	EWS GOVERNANCE - CITY LEVEL INSTITUTIONAL FRAMEWORK				
	CRITERIA	DEVELOPMENT STAGE INDICATORS				
		1	2	3	4	5
1.1	State legislation for EWS framework includes local authority (Urban Local Body) as an integral part **(document, control to the ULB)**	Not envisaged	Need is realized, changes in legislation are in process	In place, but not implemented	In place, partially implemented	In place and implemented
1.2	Institutional mechanism for Local Authority (ULB) is an integral part of EWS framework **(document, mandate, implementation)**	Not envisaged	Need is realized, changes in institutional mechanism are being brought about	In place, but mandate remains unclear	In place, but partially implemented	In place and implemented
1.3	ULB accorded with the authority to disseminate warnings **(mandate, SOP, implementation)**	Not envisaged	Mandate does not exist but informal dissemination happens	Mandate exists for dissemination with no SOP in place	Mandate and SOPs in place, implementation not effective	Mandate and SOP in place with effective implementation
1.4	Extent of preparedness and prevention actions evident among state technical and disaster management agencies **(relevant department DM Plan at state, SOPs, link from state to city)**	Select departments have DM Plan, but it is not implemented	All departments have DM Plan, partially implemented	All departments have DM Plan and SOP in place and implemented, but not integrated across	All departments have DM Plan, SOP in place, implemented and integrated across state departments	All departments have DM Plan, SOP in place, implemented, integrated across state departments and with links to the city

S. NO.	COMPONENT 2	USER NEEDS				
	CRITERIA	DEVELOPMENT STAGE INDICATORS				
		1	2	3	4	5
2.1	Hotspots identified for potential hazard impact (identified, mapped and updated)	Hotspots not identified	Hotspots vaguely identified through past incidence records, not demarcated	Hotspots identified and mapped across city for selected hazards	Hotspots identified and mapped across the city for all hazards, not updated at regular intervals	Hotspots identified and zone of demarcation updated on regular intervals
2.2	Outreach practice (dissemination of warning)	No formal practice for any hazard	Only for select hazards to key government institutions and media	All hazards to key government institutions and media	All government institutions, media, community based organizations	Last mile connectivity established (End-to-End), specific information to select vulnerable communities
2.3	Timely dissemination of warnings to vulnerable groups (residing in slums, high risk prone areas)	No specific warning for vulnerable groups exists in the city	Dissemination of warning exists to some extent	Dissemination of warning exists for select hazards, but with limited respite time	Dissemination of warning exists for all hazards, but with limited respite time	Dissemination of warning exists, with sufficient respite time
2.4	Arrangement for night-time warning (limited to floods, landslides, cyclones,tsunamis)	No specific arrangement for warning in night time	Recognition of the need, planning in progress	Night-time warning is recognized and arrangements reflect this, scope for considerable improvement in dissemination/ outreach	Night-time warning dissemination and outreach established	Warning dissemination tested through conduct of emergency night-time drills/event
2.5	Media engagement in dissemination of warning	Limited coverage, media collects information from respective agencies, shortcomings in communication	Limited coverage of information from respective agencies, technical information presented as received from agencies, shortcomings in communication, problem recognized but not addressed	Media collects and disseminates information, shortcomings are being addressed through collaboration with agencies	Media collects information from technical agencies, timely dissemination of warning to citizens in an understandable format (authenticated value addition)	Standardized content with graphical/iconic representation, near real time updates, citing possible impacts
2.6	Content of warning to general public by local government (ULB) (graphical representation and behavioural content for taking actions at individual/household and community levels)	Limited information	Adequate information for select hazards, but with no behavioural content	Adequate information for relevant hazards, but with no behavioural content	Warning information with graphical, factual representation and general behavioural content at city level	Warning information with graphical, factual representation at ward level and contextual behavioural information provided

S. NO.	COMPONENT 3	OPERATIONAL COMPONENTS OF EWS				
	CRITERIA	DEVELOPMENT STAGE INDICATORS				
		1	2	3	4	5
TECHNICAL AGENCIES						
3.1	Risk assessment and integration with potential impact assessment (identification, mapping, integration)	Risk assessment does not exist	Risk prone areas identified based on historical data, past disasters and other qualitative information in the form of institutional memory and tabular records	Risk assessment undertaken with technical information and demarcates risk prone administrative units, risk assessment products available in the form of maps and quantitative information	Risk assessment (hazard maps, vulnerability and risk maps) available on GIS platform but not updated periodically and not fully integrated with prediction component to derive potential impact assessment and stage response	Risk assessment updated periodically (available on GIS platform) and fully integrated with prediction component to derive potential impact assessment and stage focused response
3.2.1	Warning mechanism for geophysical hazards: Earthquake, Landslide and Tsunami	Warning mechanism does not exist	Warning exists with no consistency in warning message and inadequate respite time	Consistency in warning message with inadequate respite time	Consistency in warning message with adequate respite time	Advanced warning protocol with adequate respite time (with multiple relay and deactivation process)
3.2.2	Warning mechanism for hydrometeorlogical hazards: Cyclone, Severe Winds, Stormsurge, Heatwave, Coldwave, Snow, Extreme Rainfall, Fluvial Flood and Pluvial Flood	Warning mechanism does not exist	Warning exists with no consistency in warning message and inadequate respite time	Consistency in warning message with inadequate respite time	Consistency in warning message with adequate respite time	Advanced warning protocol with adequate respite time (with multiple relay and deactivation process)
3.2.3	Warning mechanism for public health risks: Vector borne diseases, Water borne diseases and other communicable diseases	Advisory does not exist	General advisory exists with no indication of areas and vulnerable groups	Advisory exists for vulnerable groups with no demarcation of areas	Demarcation of areas based on active and passive surveillance with time delay, no involvement of private stakeholders	Near real time warning, protocol established, active and passive surveillance along with involvement of private stakeholders
3.3.1	Availability of technology to nowcast/ forecast of geophysical hazards by technical agencies	High dependency on national agencies for observation, monitoring and forecasting	Has sufficient technology to observe, monitor and nowcast/forecast at regional level, with high dependency on technology available at regional centres	Has sufficient technology to observe, monitor and nowcast/ forecast at district level	Has sufficient technology to observe, monitor and nowcast/ forecast at city level	Has sufficient technology to observe, monitor and nowcast/ forecast at community level/hotspots

S. NO.	COMPONENT 3	OPERATIONAL COMPONENTS OF EWS				
	CRITERIA	DEVELOPMENT STAGE INDICATORS				
		1	2	3	4	5
3.3.2	Availability of technology in nowcast/ forecast of hydro-meteorological hazards by technical agencies	High dependency on national agencies for observation, monitoring and forecasting	Has sufficient technology to observe, monitor and nowcast/forecast at regional level, with high dependency on technology available at regional centres	Has sufficient technology to observe, monitor and nowcast/ forecast at district level	Has sufficient technology to observe, monitor and nowcast/ forecast at city level	Has sufficient technology to observe, monitor and nowcast/ forecast at community level/hotspots
3.3.3	Disease surveillance system (surveillance coverage, collection method, analysis)	Surveillance exists at district level using paper-based forms; analysis undertaken at district level	Surveillance exists at city level within government hospitals using paper-based forms; analysis undertaken at city level	Surveillance exists at city level within government hospitals, private hospitals and all clinics; using paper-based forms; analysis undertaken at city level	Surveillance exists at city level within government hospitals, private hospitals and all clinics; using computerized data collection; analysis and mapping undertaken at community level	Detailed surveillance is carried out on a near real time basis, disease forecast information is made available for decision making
3.4	Uncertainty in forecast and warning: Geophysical hazards, Hydro-meteorological hazards and Public health risks	Forecast/warning does not exist	Forecast exists with high uncertainty, and no warning exists	Forecast exists with high uncertainty, followed by incomprehensible warning	Warning based on forecast exists, with medium degree of uncertainty	Warning based on forecast exists, with low degree of uncertainty
DISASTER MANGEMENT AGENCY / LOCAL AUTHORITY (ULB)						
3.5	Budget allocation by the local authority for EWS	Budget head doesn't exist	Budget head doesn't exist, currently being spent from miscellaneous heads	Need for DM budget head realized, plan to incorporate budget for Disaster Management	Budget exists for DM, no specific budget head exists for EWS	Budget exists for DM, specific sub-head for EWS exists
3.6	Data availability for operations of EWS	Data available with different agencies in multiple formats, not collated or aggregated, qualitative information available	Data is collated from different departments, partial digitization undertaken but not updated regularly; currently not in usable format	Data is collated and updated regularly, limited quality assurance and quality control, temporal data available, spatial data not available, data is of limited use	Data is collated and updated regularly, quality assurance and quality control, temporal and spatial data available, data available in limited usable format	Standardized spatial and temporal data are collated and updated regularly for city EWS, single window system exists for data updation and dissemination, data available in usable format

S. NO.	COMPONENT 3	OPERATIONAL COMPONENTS OF EWS				
	CRITERIA	DEVELOPMENT STAGE INDICATORS				
		1	2	3	4	5
3.7	Staffing and capacity within local authority for operation and maintenance of EWS	No dedicated staff for EWS	Staff deputed on need basis, not specifically trained for operating EWS	Manpower hired on short-term basis, limited training and capacity building provided	Staff assigned for EWS but with multiple responsibility (other than EWS), limited training and capacity building provided	Dedicated specialized staff assigned for city EWS, training and capacity building of staff conducted at regular intervals
3.8	Use of modern technology to disseminate warnings	Generic media – newspapers, local cable channel and radio	In addition to generic media, public addressal system (PAS) in place, but limited to siren	In addition to generic media, PAS in place, but limited to siren and digital display at select locations	Fixed and vehicle mounted PAS, digital/ electronic display screen at select locations, mobile (SMS), web, community radio	State-of-art alert and warning system, dedicated channel, online dissemination system
3.9	Redundancy (multi-mode) in communication networks	None	Recognition of need, no special arrangements made	Recognition of the need and development in process	Warning system reflects the arrangement, partially developed, but scope for considerable improvement	Well-developed redundancy in communication network
3.10	City Emergency Operations Centre (EOC) for housing information related to hazard, vulnerability and risk	EOC does not exist	EOC is activated on a need basis, no information on hazard/ vulnerability and risk	Need for permanent EOC recognized by ULB, and development in progress	EOC established with limited technical and human resource support, and has information on hazard/ vulnerability and risk	EOC established with adequate technical and human resources (manned 24X7), SOP for EOC, systems exist to provide risk information and disseminate it to stakeholders for preparedness and response on near real time basis

S. NO.	COMPONENT 4	PRODUCTS AND SERVICES ACROSS THE WARNING CHAIN				
	CRITERIA	DEVELOPMENT STAGE INDICATORS				
		1	2	3	4	5
4.1	Degree of local details incorporated in warnings	Only generalized warnings from technical agencies	Generalized warnings from technical agencies, need for incorporation of local details is recognized, system under development	City level macro details are incorporated within warnings	Ward details (including hot spots) are incorporated within warnings	Sub-ward/locality/community details incorporated in warnings (including ward, hotspots); measures cited to take action
4.2	Raising awareness about warnings at city level	No efforts are being made to sensitize citizens	Efforts are made to raise public awareness on frequent hazards, need basis	Awareness programmes on frequent hazards and their risks are conducted on regular/seasonal intervals, special population needs are also not addressed and programme not evaluated	Comprehensive programmes on all hazards and their risks are conducted on regular basis, special population needs addressed, but programme not evaluated	Comprehensive programmes on all hazards and their risks are conducted to raise the level of public awareness, programme regularly evaluated and strengthened
4.3	Ability of technical agencies and disaster management institutions to cater to early warning products and services to user specific requirements	User need assessment not undertaken	User need assessment undertaken, products identified	Products generated for select hazards catering to selected users	Products generated for select hazards catering to selected users, details available to take actions	Products generated for all hazards catering to all users, and details available to take actions
4.4	Risk communication	Risk assessment does not exist, hence no communication	Risk not assessed in local context, information generated by technical agencies are transferred and published/disseminated	Risk is assessed in local context and communicated to select stakeholders	Risk communication including preparedness measures are communicated to stakeholders, dissemination is not robust (last mile connectivity is not ensured)	Well-established risk communication mechanism enables stakeholders to manage risk, dissemination is robust (last mile connectivity is ensured)

S. NO.	COMPONENT 5	COORDINATION MECHANISM				
	CRITERIA	DEVELOPMENT STAGE INDICATORS				
		1	2	3	4	5
5.1	Extent of coordination between technical agencies and disaster management agencies	Communication is limited to select agencies	Communication with all agencies exist, coordination does not exist	Communication with all agencies exist, limited coordination exists	Coordination mechanism ensures agencies respond to specific needs	Coordination ensures collective decision making
5.2	Extent of links between disaster management agencies and service providers	No formal links exist, service providers depend on information hosted on public domain	Formal links do not exist, select service providers are informed during the onset of an event	Formal links become active only prior to/ during an event	Formal links become active periodically in anticipation of an event, one way communication initiated from disaster management agency	Formal links become active periodically in anticipation of an event, two way communication established to ensure business continuity, co-benefit achieved
5.3	Extent of links between media and disaster management agencies	Media depend on information hosted on public domain	Limited information is provided to media	Collaboration and reflection of warning information in the media products are evident	Active collaboration exists, understanding of warnings are reinforced through discussions, no value addition	Well-developed links exist, seamless flow of information, value addition to warning is evident

S. NO.	COMPONENT 6	SERVICE DELIVERY AND FEEDBACK LOOPS				
	CRITERIA	DEVELOPMENT STAGE INDICATORS				
		1	2	3	4	5
6.1	User community's knowledge of early warning system and its effectiveness	ULB does not have clear understanding of existing early warning systems	ULB is aware of early warnings, but does not initiate action	ULB and service providers are aware of warnings, but impacts are not clear to initiate or coordinate action	ULB and service providers are knowledgeable of warnings and are able to take coordinated action	ULB, service providers and citizens are knowledgeable of warnings and are able to take informed actions
6.2	Extent to which the warning mechanism allows for feedback from affected area	No feedback mechanism exists	Problem recognized and mechanism under development	Feedback mechanism exists, but does not include all stakeholders	Feedback mechanism includes all stakeholders, but is not robust	Feedback mechanism functions in near real time
6.3	Level of reflection and learning evident within local authority	Post event reflection is done, but no change is evident	Post event reflection is done and change is evident in mode of communication	Post event reflection is done and change is evident in communication and response mechanism	Assessment undertaken, change evident in monitoring/forecasting/ warning and subsequent increase in respite time	Along with increased respite time there is change in guidelines and standard operating procedures
6.4	Monitoring, evaluation and targets for improvement of EWS	No formal procedure to monitor the EWS performance is in place	Need realized, M&E process is under development	Monitoring of select EWS components are in place, improvement needed	M&E process is in place, not undertaken at regular intervals	M&E process is in place and is being carried out regularly, targets for improvements are outlined

4. UNDERSTANDING EWS AND KEY FRAMEWORKS FOR GEOLOGICAL HAZARDS, HYDRO-METEOROLOGICAL HAZARDS AND PUBLIC HEALTH RISKS

Every type of hazard has its own dynamics. The duration of the phenomenon will vary for hazard type and the event type (small or big). There are various stages associated with the development of the event (Figure 5). Broadly, the stages can be categorized as follows:

- Embryonic stage can be linked to the manifestation of those conditions that may give rise to these events or as the events begin to emerge; preliminary phase of the event.
- Growth stage is when the event gradually evolves in terms of its magnitude or area of influence.
- Mature stage would represent the event as being capable of provoking a disaster in a particular geographic location; event triggers impacts and effects on communities and regions near its path.
- Decaying stage that indicates when the event loses its strength and is dissipating.

In the context of early warning, the time lapse between the embryonic and the mature stage is determinant to the capacity of issuing warnings. If this time lapse is large enough, hierarchical phases could be identified allowing for the establishment of several alert or warning levels.

For example, in case of a tropical cyclone in the Indian Ocean, the disturbance that gives rise to the event and subsequent shaping up is considered as embryonic stage. The growth stage would then encompass those processes related to evaporation of water from the ocean and the convective processes within the atmosphere that begin to take shape, such tropical cyclone. In the

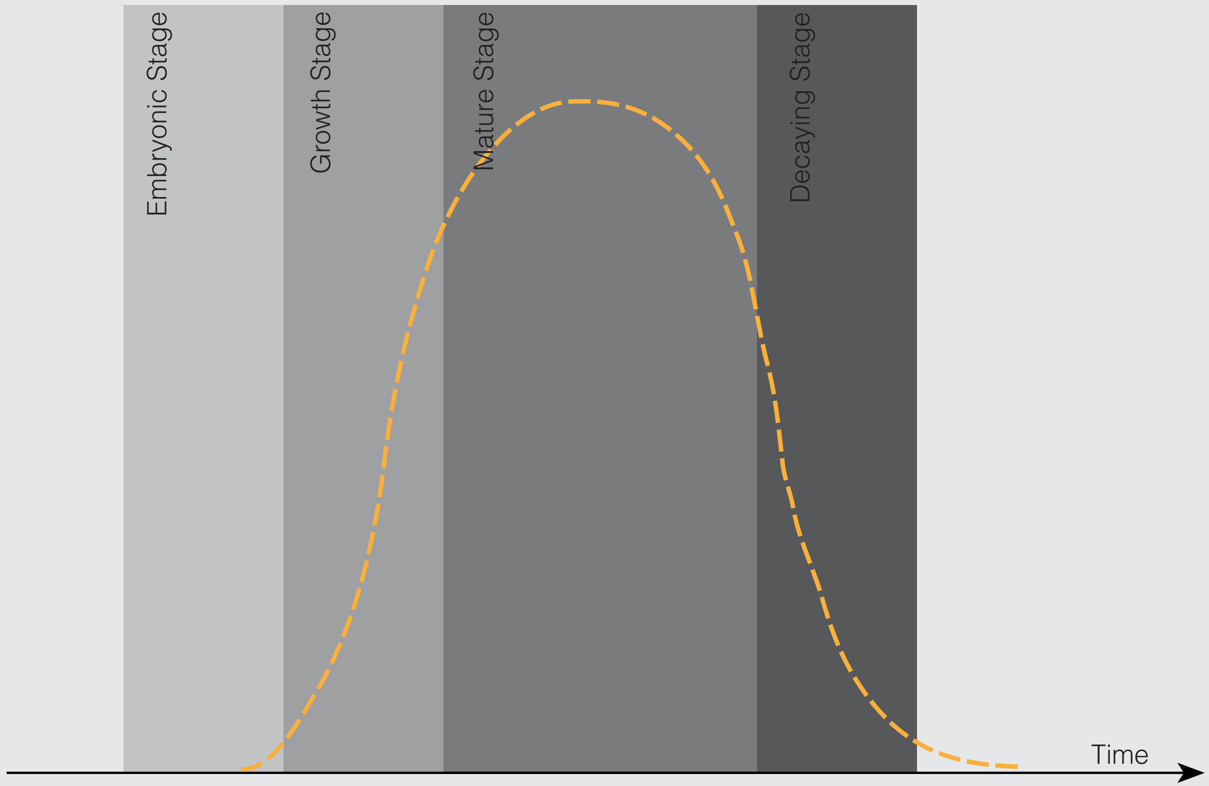


Figure 5: Evolution of an hazard event in four stages

Source: Villagrán de León, J. C., Pruessner, I., and H. Breedlove (2013). Alert and Warning Frameworks in the Context of Early Warning Systems. A Comparative Review. Intersections No. 12. Bonn: United Nations University Institute for Environment and Human Security.

mature stage, one could see the cyclone as fully manifested in terms of its typical characteristics such as very low barometric pressure, high wind speeds, storm surges and precipitation. Finally, as the cyclone makes landfall, it begins to weaken to the point that it ceases to exist once it is fully inside large landmasses. In this context, meteorologists use a variety of instruments to track the four stages of events. A combination of measurements and computing allows the IMD Cyclone Warning Division to be able to follow the path and the dynamics of such events, leading to forecasts of trajectories and places where such cyclone may make landfall. The disaster management agencies take actions based on the information provided by the technical agencies and follow the Standard Operating Procedure as outlined in the Disaster Management Plan.

4.1 EWS Framework for Earthquake Hazard

Earthquake occurs due to plate tectonic activity. The India sub-continent has a history of devastating earthquakes. Some regions of the country are more risk prone than others. As per the seismic hazard zoning map of India, India is broadly divided into four zones. Zone V is very high damage risk zone (Intensity IX and above on MSK scale); Zone IV is high damage risk zone (Intensity VIII on MSK scale), Zone III is moderate damage risk zone (Intensity VII on MSK scale) and Zone II is low damage risk zone (Intensity VI or less on MSK scale). About 59 per cent of the geographical region of the country falls under Zones III, IV and V.

Studies indicate the possibility of earthquakes of severe intensity in some parts of the country. Given the high vulnerability of the country to

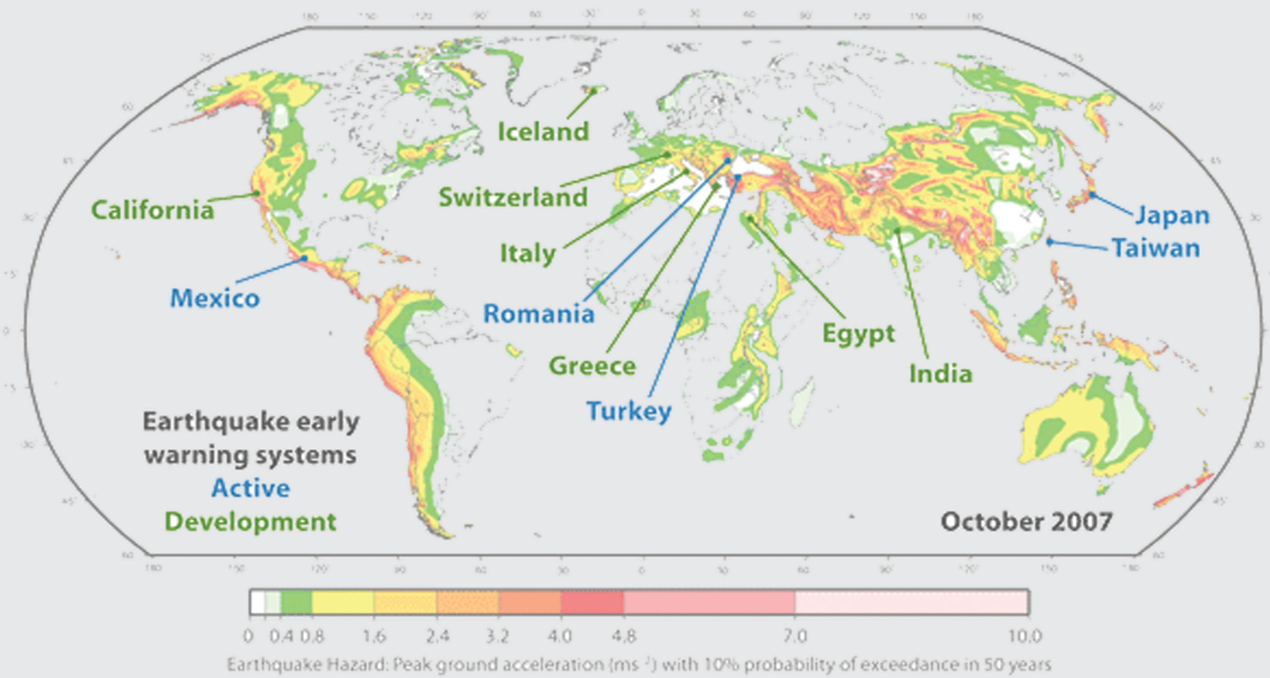


Figure 6: Global earthquake hazard map showing the regions operating active earthquake early warning systems

Note: labelled in blue. The regions developing early warning systems are labelled in green
Source: http://www.elarms.org/front/eewGlobal.php Last accessed on 18 April 2014

damaging earthquakes, there is no functional EWS for earthquake hazard. The growth stage of an earthquake may span across centuries, whereas the phenomenon of ground shaking lasts for seconds to a few minutes. Once the event takes place, the main shock is followed by aftershocks. In some cases, the large earthquake may be preceded by foreshocks. Earthquakes below the ocean bed can trigger tsunami, and on land they can trigger landslides, mudslides, avalanche and rock fall.

Earthquake EWS takes advantage of the rapid availability of earthquake information to quantify the hazard associated with an earthquake and issue a prediction of impending ground motion prior to the arrival of the strong waves in populated areas. Earthquake EWS is a combination of instrumentation, methodology and software designed to analyse and warn the populated areas or sensitive installations. Japan, Taiwan, Mexico, Romania and Turkey currently operate Earthquake EWS, while California (California Integrated Seismic Network, CISN), Iceland, Switzerland, Italy, Greece, Egypt and India are either in the development or testing phase of Earthquake EWS. Figure 6 shows the status of countries where Earthquake EWS is operational.

India Meteorological Department (IMD) is the nodal agency of Government of India responsible for monitoring seismic activity in and around the country. The operational task of the department is to quickly estimate the earthquake source parameters immediately on occurrence of an earthquake and disseminate the information to all the user agencies including the concerned state and central government agencies responsible for carrying out relief and rehabilitation measures. Information relating to under-sea earthquakes capable of generating tsunamis on the Indian coastal regions is also disseminated to all concerned user agencies, including the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, for issue of tsunami related messages and warnings. Earthquake information is transmitted to various user agencies, including public information channels, press, media etc. using different modes of communication, such as SMS, fax, email and is also posted on IMD's website (www.imd.gov.in).

India Meteorological Department also maintains a countrywide National Seismological Network (NSN), consisting of a total of 82 seismological stations, spread over the entire length and breadth of the country. This includes: (a) 16-station VSAT based digital seismic telemetry system around National Capital Territory (NCT) of Delhi, (b) 20-station VSAT based Real Time Seismic Monitoring Network in the north-eastern region of the country and (c) 17-station Real Time Seismic Monitoring Network (RTSMN) to monitor and report large magnitude under-sea earthquakes capable of generating tsunamis on the Indian coastal regions. The remaining stations are of standalone/analogue types. A Control Room is in operation on a 24X7 basis, at IMD Headquarters (Seismology) in New Delhi, with state-of-art facilities for data collection, processing and dissemination of information to the concerned user agencies.

4.2 EWS Framework for Tsunami Hazard

Tsunamis are triggered by undersea earthquakes; landslides which reach seas or oceans and underwater landslides; volcanic eruptions and dome collapse and meteorites. It is important to note that all earthquakes do not cause tsunamis. The tsunami EWS gathered much attention in India largely because of the consequence of the Indian Ocean tsunami of 26 December 2004. Underwater mass movements get triggered by any of the factors mentioned above. The growth of the phenomenon takes place in the sea and it heads straight to the coastline impacting as tsunami waves. Rise in the sea level and impact of tsunami may last for several hours, and there can be several waves associated with a tsunami event.

In the aftermath of the Great Sumatra earthquake of 26 December 2004, the Ministry of Earth Sciences has set up an Indian Tsunami Early Warning Centre at the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad. The centre is mandated to provide advance warnings on tsunamis that are likely to affect the coastal areas of the country. As a part of this, a 17-station Real Time Seismic Monitoring Network (RTSMN) has been set up by India Meteorological Department.

The network is capable of monitoring and reporting, in least possible time, the occurrence of earthquakes capable of generating tsunamis that are likely to affect the Indian coastal regions. Data from the 17 broadband seismic field stations are transmitted simultaneously in real time through VSAT communication facilities to the Central Receiving Stations (CRSs) located at IMD, New Delhi, and INCOIS, Hyderabad, for processing and interpretation.

The CRSs are equipped with state-of-art computing hardware, communication, data processing, visualization and dissemination facilities. For providing better azimuthal coverage for detecting earthquakes with potential to cause tsunamis, the

RTSMN system has been configured to include about 100 global stations of IRIS (a consortium of Incorporated Research Institutions in Seismology), whose data are available freely through the internet. Information on earthquake is disseminated through various communication channels to all the concerned user agencies in a fully automated mode. Based on the earthquake information provided by the RTSMN and other ocean-related observations/analysis, INCOIS evaluates the potential of the undersea earthquakes to cause tsunami and issues necessary warnings/alerts as per the situation.

The National Tsunami Early Warning Centre at INCOIS is operational since October 2007 and has been issuing accurate tsunami warnings for all undersea earthquakes of ≥ 6.5 M as shown in figure 7. The ITEWS comprises a real time network of seismic stations, Bottom Pressure Recorders (BPR), tide gauges and 24X7 operational tsunami warning centre to detect the potential of earthquakes to cause tsunami, to monitor tsunamis and to provide timely advice to vulnerable community by means of latest communication methods with back-end support of a pre-run scenario database and Decision Support System (DSS). Table 2 presents the bulletin types issued by the ITEWC with the timelines.

However, as local conditions would cause a wide variation in tsunami wave action, the ALL CLEAR determination is made by the local authorities. Actions Based on Threat Status (WARNING/ALERT/WATCH) is given in the table 2.

Bulletin Type	Information	Time of Issue (Earthquake origin time as T_0 minutes)
Type I	Preliminary EQ parameters and LAND/NO THREAT information based on EQ location, magnitude and depth	T_0+20
	Preliminary EQ parameters and qualitative potential of earthquake to cause tsunami, based on EQ location, magnitude and depth	
Type II	Preliminary EQ parameters and NO THREAT information from model scenarios	T_0+30
	Preliminary EQ parameters and quantitative tsunami threat (WARNING/ALERT/WATCH) information from model scenarios	
Type II Supplementary - xx	Revised EQ parameters and quantitative tsunami threat (WARN-ING/ALERT/WATCH) information from model scenarios – if revised EQ parameters are available much before the real time water level observations are reported	As and when revised earth-quake parameters are available or after earthquake lapsed Time + 60 min
Type III	Revised EQ parameters and quantitative tsunami threat (WARN-ING/ALERT/WATCH) information from model scenarios and real time water level observations indicating tsunami generation	As and when the first real time water level observation is available
Type III Supplementary -xx	Revised EQ parameters and quantitative tsunami threat (WARN-ING/ALERT/WATCH) information from model scenarios and real time water level observations indicating tsunami generation threat PASSED information for individual zones	Hourly update/as and when he subsequent real time water level observations are avail-able
Final Bulletin	Issued when water levels from multiple gauges confirm that no significant tsunami was generated	
	120 minutes after a significant tsunami passes the last Indian threat zone	

Source: IETWC User Guide Ver. 2, Indian National Centre for Ocean Information Services, June 2011

Threat Status	Actions to be taken	Dissemination to
WARNING	Public should be advised to move inland towards higher grounds. Vessels should move into deep ocean	MoES, MHA, NDMA, NCMC, NDRF bat-talions, SEOC, DEOC, public, media
ALERT	Public should be advised to avoid visiting beaches and low-lying coastal areas Vessels should move into deep ocean	MoES, MHA, NDMA, NCMC, NDRF bat-talions, SEOC, DEOC, public, media
WATCH	No immediate action is required	MoES, MHA MoES, MHA, MEDIA, NCMC, NDRF battalions, SEOC, DEOC
THREAT PASSED	All clear determination to be made by the local authorities	MoES, MHA, NDMA, NCMC, NDRF bat-talions, SEOC, DEOC, public, media

Table 2: Bulletin types, threat status & action points for tsunami warning alert and watch

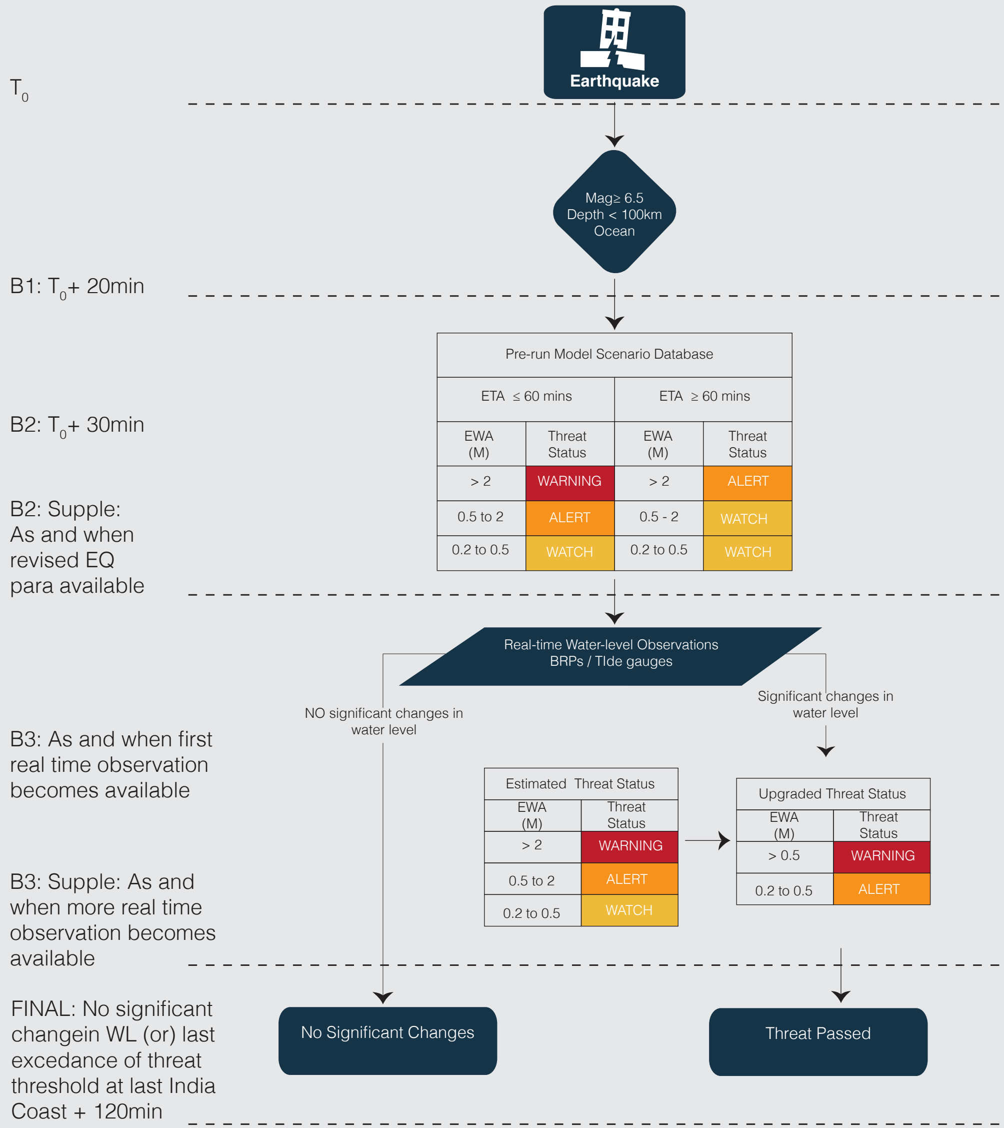


Figure 7: SOP diagram of tsunami early warning centre

Source: http://www.tsunami.incois.gov.in/ITEWS/dss_sop.jsp (Last accessed on 18 April 2014)

4.3 EWS Framework for Landslide Hazard

The term 'landslide' describes a wide variety of processes that result in the downward and outward movement of slope-forming materials, including rock, soil, artificial fill or a combination of these. The materials may move by falling, toppling, sliding, spreading or flowing (USGS). Landslide causes can be classified into four categories:

- Geological causes: These include weak, weathered, sheared or fissured materials, adversely-oriented structural discontinuities (faults, unconformity, etc.), and contrasts in permeability and stiffness.
- Morphological causes: These include tectonic or volcanic uplift, glacial rebound, fluvial, glacial or wave erosion of slope toe, or vegetation removal (by forest fire, drought).
- Physical causes : These include intense rainfall, rapid snow melt; earthquakes, volcanic eruptions, thawing and weathering (freeze and thaw or shrink and swell).
- Anthropogenic causes : These include excavation of the slope or its toe, loading of the slope or its crest, deforestation, irrigation, mining, artificial vibration and water leakage from utilities.

Landslide, a frequently occurring natural hazard in the hilly terrains of India, is a predominant activity during the monsoon period from July to September and after the snowfall from January to March. Strong earthquakes also trigger landslides, particularly in regions marked by critically disposed and unstable slopes. On a rough estimate, nearly 15 per cent of India's landmass or 0.49 million sq km area is prone to landslides. This includes 0.098 million sq km of the north-eastern region, comprising the Arakan

Yoma ranges, and 0.392 million sq km of parts of the Himalayas, Nilgiris, Ranchi Plateau, and Eastern and Western Ghats. As many as 20 states of India are affected by different degrees of landslides. Of these, the states of Sikkim and Mizoram have been assessed to be falling under very high to severe hazard classes. Most of the districts in the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Nagaland and Manipur come under high to very high landslide hazard classes. In the peninsular region, the hilly tracts of states like Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Goa, Madhya Pradesh and Kerala constitute low to moderate hazard prone zones.

Slope saturation by water is the common trigger of landslides, generated through processes such as intense rainfall, snowmelt, changes in groundwater levels, and water level changes along coastlines, earth dams and the banks of lakes, reservoirs, canals and rivers. Landslides and floods are closely allied because both are related to precipitation, runoff and the saturation of ground by water. In addition, debris flows and mudflows usually occur in small, steep stream channels and often are mistaken for floods; in fact, these two events often occur simultaneously in the same area. Building on the fact that some landslides are triggered by intense rainfall, institutions establish the saturation threshold and develop landslide EWS. The presence of extreme weather conditions is used as an indicator to issue warning or to change the levels of warning in the systems, which make use of various threshold levels.

The study of landslide hazard is carried out by the Geological Survey of India (GSI), and can be divided into two broad categories:

1. Pre-disaster Studies: Identification of vulnerable slopes through landslide hazard zonation (LHZ) mapping on various scales or studying the critical slopes individually and determining their status as far as their stability is concerned.

2. Post-disaster Studies: Detailed analysis of landslides that have occurred, determine the causes responsible for failure and suggest treatment measures required to stabilize the slopes.

Landslide EWS is not undertaken at the moment by GSI or by other agencies in the country.

4.4 EWS Framework for Tropical Cyclone

A tropical cyclone is a rotational low pressure system in the tropics when the central pressure falls by 5 to 6 hPa from the surroundings and the maximum sustained wind speed reaches 34 knots (about 62 kmph). It is a vast violent whirl of 150 to 800 km, spiralling around a centre and progressing along the surface of the sea at a rate of 300 to 500 km a day. The word cyclone has been derived from the Greek word cyclos, which means ‘coiling of a snake’. These events are controlled by the interaction between the atmosphere and the oceans in tropical waters. The stages of the cyclone take from a few days to few weeks. During the mature stage, the tropical cyclone may vary its characteristics in terms of wind speed and pressure based on the interaction. On hitting the land, the system weakens and dissipates. Over the last two decades, there has been significant improvement in the capacities of the institutions to monitor, forecast and warn populations in advance of the cyclone hitting the land. World Meteorological Organization has set up five Regional Specialized Meteorological Centres (RSMC) in Miami, Tokyo, New Delhi, La Réunion and Nadi.

Based on wind speed over the oceanic area, IMD has classified the low pressure systems into the following categories, from low pressure area to super cyclonic storm:

Cyclone Warning Organization Structure in India

RSMC – Tropical Cyclones, New Delhi with effect from 1 July 1988 has been assigned the responsibility of issuing Tropical Weather Outlooks and Tropical Cyclone Advisories for the benefit of the countries in the WMO/ESCAP Panel region bordering the Bay of Bengal and the Arabian Sea, namely, Bangladesh, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand. The main activities of RSMC, New Delhi, are listed below.

- Round-the-clock watch over the entire North Indian Ocean
- Analysis and processing of global meteorological data for diagnostic and prediction purposes
- Detection, tracking and prediction of cyclonic storms in the Bay of Bengal and the Arabian Sea
- Running of numerical models for tropical cyclone track and intensity prediction
- Issue of Tropical Weather Outlook once daily (at 0600 UTC) and an additional outlook at 1700 UTC in the event of a depression, which is likely to intensify into a cyclonic storm
- Issue of cyclone advisories to the Panel countries eight times a day
- Issue of storm surge advisories
- Implementation of Regional Cyclone Operational Plan of WMO/ESCAP Panel

- Collection, processing and archival of all data pertaining to cyclonic storms, viz., wind, storm surge, pressure, rainfall, satellite information etc.
- Exchange of composite data and bulletins pertaining to cyclonic storms with Panel countries
- Preparation of comprehensive reports on each cyclonic storm
- Continued research on storm surge, track and intensity prediction techniques

Cyclone Warning Division

Cyclone Warning Directorate – located with RSMC – Tropical Cyclones, New Delhi, was established in 1990 in the Office of the Director General of Meteorology, New Delhi – to co-ordinate and supervise the cyclone warning work in the country in totality. The mission of this division is to improve the cyclone warning activity in the country and to improve links between early warning system of cyclone and disaster management.

The broad functions of the Cyclone Warning Division and RSMC – Tropical Cyclones, New Delhi are as follows:

- Round-the-clock watch over the entire North Indian Ocean
- Analysis and processing of global meteorological data for diagnostic and prediction purposes
- Detection, tracking and prediction of cyclonic storms in the Bay of Bengal and the Arabian Sea
- Issue of numbered Cyclone Warning Bulletins to AIR, Doordarshan and other TV channels and print media for wider coverage
- Interaction with disaster management agencies and providing critical information for emergency support services

System Intensity	Damage Expected	Suggested Action
Low Pressure Area (Not exceeding 17 kts or less than 31 kmph)	--	--
Depression (17–27 kts or 31–51 kmph)	--	--
Deep Depression (28–33 kts or 52–61 kmph)	Minor damage to loose and unsecured structures	Fishermen advised not to venture into the open seas
Cyclonic Storm (34–47 kts or 62–87 kmph)	Damage to thatched huts. Breaking of tree branches causing minor damage to power and communication lines	Total suspension of fishing operations
Severe Cyclonic Storm (48–63 kts or 88–117 kmph)	Extensive damage to thatched roofs and huts. Minor damage to power and communication lines due to uprooting of large avenue trees. Flooding of escape routes	Total suspension of fishing operations. Coastal hutment dwellers to be moved to safer places. People in the affected areas to remain indoors
Very Severe Cyclonic Storm (64–90 kts or 118–167 kmph)	Extensive damage to kutcha houses. Partial disruption of power and communication lines. Minor disruption of road and rail traffic. Potential threat from flying debris. Flooding of escape routes	Total suspension of fishing operations. Mobilize evacuation from coastal areas. Judicious regulation of rail and road traffic. People in affected areas to remain indoors
Very Severe Cyclonic Storm (91–119 kts or 168–221 kmph)	Extensive damage to kutcha houses. Some damage to old buildings. Large-scale disruption of power and communication lines. Disruption of rail and road traffic due to extensive flooding. Potential threat from flying debris	Total suspension of fishing operations. Extensive evacuation from coastal areas. Diversion or suspension of rail and road traffic. People in affected areas to remain indoors
Super Cyclone (120 kts or more, or 222 kmph or more)	Extensive structural damage to residential and industrial buildings. Total disruption of communication and power supply. Extensive damage to bridges causing large-scale disruption of rail and road traffic. Large-scale flooding and inundation of sea water. Air full of flying debris	Total suspension of fishing operations. Large-scale evacuation of coastal population. Total suspension of rail and road traffic in vulnerable areas. People in the affected areas to remain indoors

Reference/Source: Forecasters Guide, India Meteorological Department, 2008

Table3: Damage expected & actions from low pressure area to super cyclonic storm

- Coordination with government & other agencies at HQ level on all matters relating to cyclonic storms
- Collection, processing and archival of all data pertaining to cyclonic storms, viz., wind, storm surge, pressure, rainfall, satellite information etc.
- Preparation of comprehensive reports on each cyclonic storm
- Collection of all types of information on individual cyclonic storms from State Governments, cyclone warning centres and other agencies.
- Continued research on storm surge, track and intensity prediction techniques.

Area Cyclone Warning Centres (ACWCs)/ Cyclone Warning Centres (CWCs)

With the establishment of additional centres at Bhubaneshwar and Visakhapatnam, the Storm Warning Centres at Kolkata, Chennai and Mumbai were named as Area Cyclone Warning Centres (ACWC) and the Storm Warning Centres at Visakhapatnam, Bhubaneshwar and Ahmedabad as Cyclone Warning Centres (CWC). CWCs Visakhapatnam, Bhubaneshwar and Ahmedabad function under the control of the ACWCs – Chennai, Kolkata and Mumbai respectively.

Meteorological Centre (MC), Hyderabad, liaises between CWC Visakhapatnam and Andhra Pradesh government officials; warnings issued by CWC Visakhapatnam are sent to MC Hyderabad also for briefing the Andhra Pradesh government officials at the state capital.

The present organizational structure for cyclone warnings is a three-tier one, with the ACWCs/CWCs actually performing the operational work of issuing the bulletins and warnings to the various user

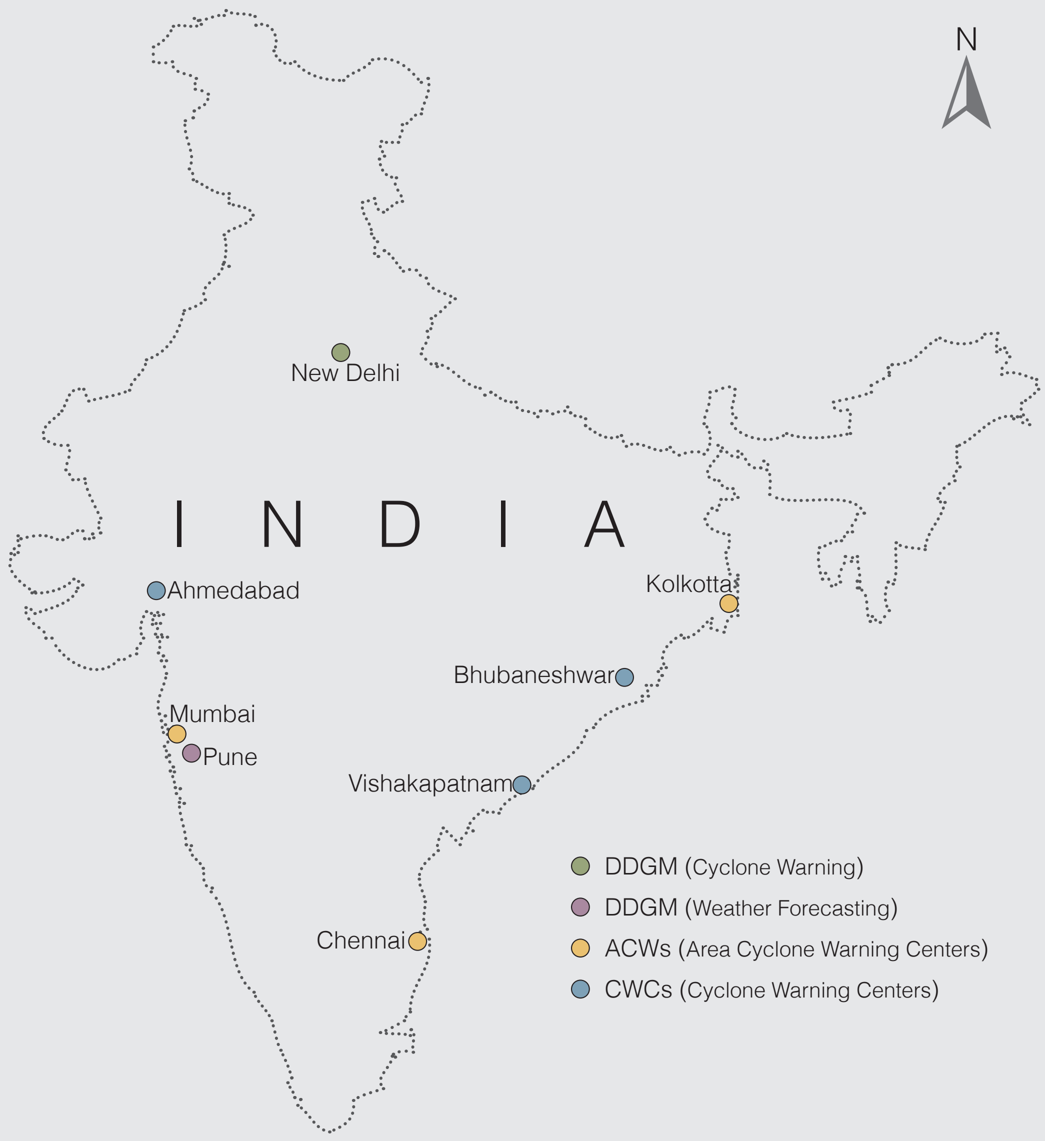


Figure 8: Cyclone warning organization structure

Source: http://www.imd.gov.in/section/nhac/dynamic/cwo.pdf interests, while the Cyclone Warnings (Directorate) New Delhi and the Deputy Director General of Meteorology (Weather Forecasting), through Weather Central, Pune, coordinate and guide the work of the ACWCs/CWCs, exercise supervision over their work and take necessary measures for continued improvement and efficiency of the storm warning systems of the country as a whole. The ultimate responsibility of carrying on storm warning work, however, rests with the ACWCs and CWCs. The ACWCs/CWCs maintain round-the-clock watch.

Bulletins and Warnings Issued by ACWCs and CWCs

The following is the list of bulletins and warnings issued by the ACWCs and CWCs for their respective areas of responsibility:

- Weather and sea bulletins
  - for shipping on the high seas and (issued by ACWCs Mumbai and Kolkata only)
  - for ships plying in coastal waters
- Bulletins for Indian Navy (issued by ACWCs Mumbai and Kolkata only)
- Bulletins for departmental exchanges (issued by ACWCs Mumbai, Kolkata and Chennai)
- Port warnings
- Fisheries warnings
- Pre-cyclone watch and post landfall outlook (issued by Cyclone Warning Division)
- Bulletins for the AIR
- CWDS bulletins
- Warnings for registered/designated users
- Bulletins for the press
- Aviation warnings (issued by concerned aviation meteorological offices)

4.5 EWS Framework for Floods

Floods are triggered by heavy rainfall and due to systems such as the cyclone. In some cases, the event can manifest quickly as in flash floods, and in some cases, it can last for days to manifest itself as in very large basins. The fact that most floods are preceded by heavy rainfall, which leads to increasing runoff in the basis and subsequent rise in the level of rivers, the phenomenon allows for EWS to be designed and operated. In addition, if there is a reservoir located upstream, the rule book can incorporate EWS into the operational procedure of the reservoir (flood control).

The EWS for floods can be positioned as a centralized system (managed by agencies like the Central Water Commission) or can be decentralized in the case of a particular city or community-operated EWS.

Flood Forecasting & Warning Organization

In the year 1958, CWC commenced the flood forecasting service in a small way by establishing flood forecasting unit for issuing water level forecasts of the Yamuna for the National Capital, Delhi. On the recommendation of various committees/panels, a Flood Forecast and Warning Organization was set up in CWC in 1969 to establish forecasting sites on inter-state rivers at various flood prone places in the country. The National Flood Forecasting and Warning Network of Central Water Commission, comprises 175 flood forecasting sites, including 28 inflow forecasting sites in flood season (Figure 9).

Central Water Commission, through its 20 flood forecasting divisions, issues forecasts to the various user agencies, which include civil/engineering agencies of the State/Central Governments such as irrigation/revenue/railways/public undertakings and Dam/Barrage Authorities/District Magistrates/ Sub-divisional Officers besides the Defence Authorities involved in the flood loss mitigation work. During the flood season, the Honourable Minister of Water Resources, Government of India, the Chairman and the Member (River Management) of Central Water Commission are apprised of the latest flood situations in the above river basins in the country.

Classification of Various Flood Situations

The Central Water Commission has categorized various flood situations for monitoring the floods in the country though its flood forecasting network, into the following four categories, depending upon the severity of floods, based on flood magnitudes.

Level Forecast

- LOW FLOOD: The river is said to be in LOW FLOOD situation at any flood forecasting site when the water level of the river touches or crosses the warning level, but remains below the danger level of the forecasting site.
- MODERATE FLOOD: If the water level of the river touches or crosses its danger level, but remains 0.50 m below the highest flood level of the site (commonly known as HFL) then

the flood situation is called the MODERATE FLOOD situation.

- HIGH FLOOD: If the water level of the river at the forecasting site is below the highest flood level of the forecasting site but is still within 0.50 m of the HFL, then the flood situation is called HIGH FLOOD situation. In this situation, a special Orange Bulletin is issued by the Central Water Commission to the user agencies, which contains the 'special flood message' related to the high flood.
- UNPRECEDENTED FLOOD: The flood situation is said to be UNPRECEDENTED when the water level of the river crosses the HFL recorded at the forecasting site so far. In this situation, a special Red Bulletin is issued by the Central Water Commission to the user agencies, which contains the 'special flood message' related to the unprecedented flood.

Inflow Forecast

Inflow forecasts are issued for 28 dams/reservoirs/ barrages in various river basins in the country. The project authorities have identified the threshold inflow limits for issue of forecast considering various factors such as safety of the dam, status of the reservoir, downstream channel/canal requirements.

Standard Operating Procedure (SOP) for Flood Forecasting and Warning

The basic activity of data collection, its transmission and dissemination of flood forecasts to the local administration is carried out by the field divisions of CWC. The modelling centres and Divisional Flood Control Rooms (DFCR) are located in the premises of the field divisions. The field divisions perform these activities as per the existing Manual on Flood Forecasting, which contains the following critical activities as the general SOPs:

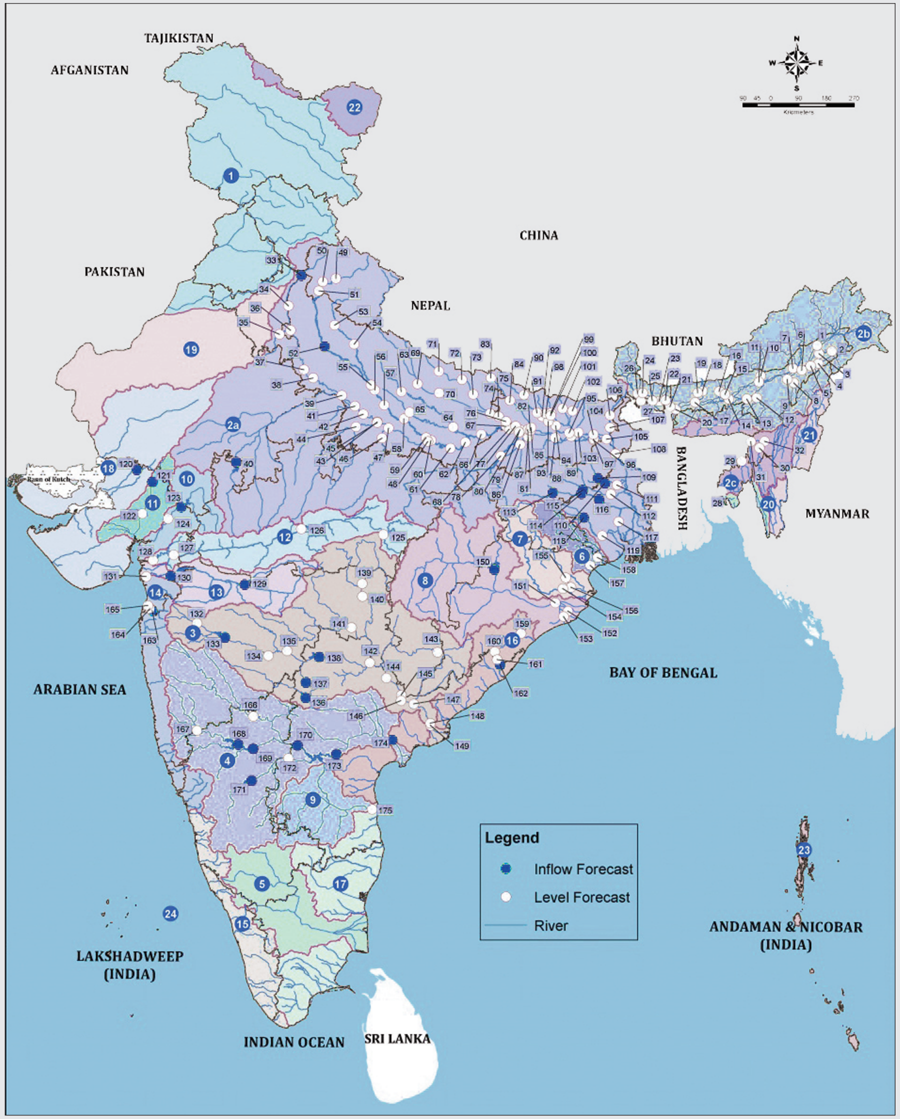


Figure 9: Flood forecasting stations in India

Source: http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=CWC_National_Flood_Forecasting_Network. Last accessed on 19 April 2014

1. Nomination of Nodal Officers of CWC for interaction with the Nodal Officers of the concerned State Governments before monsoon every year

2. Gearing up of flood forecasting network before monsoon every year

3. Operation of Divisional Flood Control Room during monsoon every year

4. Operation of Central Flood Control Room (CFCR) during monsoon every year

5. Issue of flood forecasts to designated officer of the concerned state and transmission thereof through FAX/telephone/email/through special messengers during monsoon every year

6. Sending flood alerts through SMS on mobile phones to the concerned officers of State/Central Government during high and unprecedented flood situations as per Standard Operating procedure (SOP) for issuing alerts and electronic messaging in the event of disaster situations issued by National Disaster Management Division, Ministry of Home Affairs, vide letter No: 31-32/2003-NDM-III/II dated 10 April 2006, made effective from 24 April 2006.

For the purpose of dissemination of alerts to PMO/ Cabinet Secretariat, a uniform system has been devised by categorizing each type of alert in stages – Yellow, Orange and Red.

4.6 EWS Framework for Heat Wave Condition

Heat wave conditions develop over major parts of the country during the mid-season, which often persist until the monsoon advances over the region. Heat wave need not be considered till the maximum temperature of a station reaches at least 40 °C for plains and at least 30 °C for hilly regions. The specifications for declaring the heat/cold wave conditions have been revised three times by IMD so far, viz., in 1978, 1989 and last in 2002. The revised criteria are prevalent with effect from 1 March 2002, along with some additional circulars on comfort index-based temperature forecast, description of 24-hour temperature tendency etc. When the actual maximum temperature remains 45 °C or more, irrespective of normal maximum temperature, heat wave should be declared.

Hot Day – In the northern plains of the country, dust in suspension occurs for several days, bringing the minimum temperature much higher than normal and keeping the maximum temperature around or slightly above normal. Sometimes, increase in humidity also adds to this discomfort. Nights do not get cool and become uncomfortable. To cover this situation, hot day concept has been introduced. Whenever the maximum temperature remains 40°C or more and minimum temperature is 5°C or more above normal, it may be defined as Hot Day, provided it does not satisfy the heat wave criteria given above. Criteria for describing Hot Day for coastal stations are different. When the maximum temperature departure is 5°C or more from normal, Hot Day may be described irrespective of the threshold value of 40°C. If the threshold value of 40°C is reached, Heat Wave may be declared. When a station satisfies both the Heat Wave and Hot Day criteria, then Heat Wave should be given higher priority and be declared.

Hot Wind – Hot wind reduces moisture causing dehydration, and prolonged exposure may prove to be fatal. The phenomenon of Loo (heat wave) over the plains of northwest India is very well-known. It is also described in the weather bulletins and appropriate warnings are issued.

Comfort Index – As per the recommendation of Annual Monsoon Review Meeting, 2004 (Kolkata, January 2004), it has been decided to replace the mere descriptions of maximum and minimum temperatures in weather reports and daily weather summaries by suitable comfort index, based on temperature and humidity as described below with reference to issuance of local forecast at forecasting centres. The recommendations cited are as follows:

1. Present procedure of issuing local forecast for meteorological parameters, including heat and cold waves, is to continue.

2. In addition to the above forecast, supplementary forecast based on human discomfort utilizing the Heat Index (HI) may be introduced on a trial basis for one year.

3. The HI is to be calculated based on the forecast of maximum temperature and that of relative humidity. Suggested criteria and terminology for issuing human discomfort information are given below. For day time, the criteria will be considered only when the departure of maximum temperature is above 2°C.

4. Regarding discomfort due to low temperatures during winter season, the present criteria using the wind chill index may continue.

5. The use of issuing discomfort forecast will be reviewed after one year based on the feedback from users.

Temp.	Relative Humidity (%) 40	45	50	55	60	65	70	75	80	85	90	95	100
110 (43)	136 (58)												
108 (42)	130 (54)	137 (58)											
106 (41)	124 (51)	130 (54)	137 (58)										
104 (40)	119 (48)	124 (51)	134 (55)	137 (58)									
102 (39)	114 (46)	119 (48)	124 (51)	130 (54)	137 (58)								
100 (38)	109 (43)	114 (46)	118 (48)	124 (51)	129 (54)	136 (58)							
98 (37)	105 (41)	109 (43)	113 (45)	117 (47)	123 (51)	128 (53)	134 (57)						
96 (36)	101 (38)	104 (40)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	132 (56)					
94 (34)	97 (36)	100 (38)	103 (39)	106 (41)	110 (43)	114 (46)	119 (48)	124 (51)	129 (54)	136 (58)			
92 (33)	94 (34)	96 (36)	99 (37)	101 (38)	106 (41)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	131 (55)		
90 (32)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	103 (39)	106 (41)	109 (43)	113 (45)	117 (47)	122 (50)	127 (53)	132 (56)
88 (31)	88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	98 (37)	100 (38)	103 (39)	106 (41)	110 (43)	113 (45)	117 (47)	121 (49)
86 (30)	86 (29)	87 (31)	88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	102 (39)	106 (41)	108 (42)	112 (44)
84 (29)	83 (28)	84 (29)	85 (29)	86 (30)	88 (31)	89 (32)	90 (32)	92 (33)	94 (34)	96 (36)	98 (37)	100 (38)	103 (39)
82 (28)	81 (27)	82 (28)	83 (28)	84 (29)	84 (29)	86 (29)	86 (30)	88 (31)	89 (32)	90 (32)	91 (33)	93 (34)	95 (35)
80 (27)	80 (27)	80 (27)	81 (27)	81 (27)	82 (28)	82 (28)	83 (28)	84 (29)	84 (29)	85 (29)	86 (30)	86 (30)	87 (31)

Uncomfortable hot day/night
Uncomfortable sultry day/night
Highly uncomfortable day/night
Highly uncomfortable sultry day/night

Figure 10: Heat Index °F (°C)

Source: Forecasting Guide, IMD (2008)

Category	**Heat Index**	**Possible Heat disorders for people in high risk groups**
Extreme Danger	130°F (54°C) or higher	Heat stroke or sunstroke likely
Danger	105-129°F 41-54°C	Sunstroke, muscle cramps and/or heat exhaustion likely. Heat-stroke possible with pro-longed exposure and/or physical activity
Extreme Caution	90-105°F 32-41°C	Sunstroke, muscle cramps and/or heat exhaustion possible with prolonged exposure and/or physical activity
Caution	80-90°F 27-32°C	Fatigue possible with prolonged exposure and/or physical activity

4.7 EWS Framework for Public Health Risks

Integrated Disease Surveillance Project (IDSP) was launched in November 2004 to detect and respond to disease outbreaks quickly. The programme continues in the 12th Plan under NRHM.

Surveillance units have been established in all states/districts (SSU/DSU). Central Surveillance Unit (CSU) has been established and integrated with the National Centre for Disease Control, Delhi.

Training of state/district surveillance teams and Rapid Response Teams (RRT) has been completed for all 35 states/UTs.

IT network connecting 776 sites in States/District HQ and premier institutes has been established with the help of National Informatics Centre (NIC) and Indian Space Research Organization (ISRO) for data entry, training, video conferencing and outbreak discussion.

Under the project, weekly disease surveillance data on epidemic prone disease are being collected from reporting units such as sub-centres, primary health centres, community health centres, hospitals, including government and private sector hospitals, and medical colleges. The data are being collected on 'S' syndromic, 'P' probable and 'L' laboratory formats using standard case definitions. Presently, more than 90 per cent districts report such weekly data through email/portal (www.idsp.nic.in). The weekly data are analysed by SSU/DSU for disease trends. Whenever there is rising trend of illnesses, it is investigated by the RRT to diagnose and control the outbreak.

States/districts have been asked to notify the outbreaks immediately to the system. On an average, 30 to 40 outbreaks are reported every week by the states. About 553 outbreaks were reported and responded to by the states in 2008, 799 outbreaks in 2009, 990 in 2010, 1675 outbreaks in 2011, 1584 outbreaks in 2012, 1964 outbreaks in 2013 and 67 outbreaks in 2014 have been reported till 26 January 2014.

Media scanning and verification cell was established under IDSP in July 2008. It detects and shares media alerts with the concerned states/districts for verification and response. A total of 2595 media alerts were reported from July 2008 to January 2014. Majority of alerts were related to diarrhoeal diseases, food poisoning and vector-borne diseases.

A 24X7 call centre was established in February 2008 to receive disease alerts on a toll free telephone number (1075). The information received is provided to the states/districts surveillance units for investigation and response. The call centre was extensively used during H1N1 influenza pandemic in 2009 and dengue outbreak in Delhi in 2010. About 2,77,395 lakh calls have been received from the beginning till 30 June 2012, out of which 35,866 calls were related to influenza A H1N1. From November 2012, a total of 57,855 calls were received till January 2014, out of which 1605 calls were related to H1N1.

About 50 district laboratories are being identified and strengthened for diagnosis of epidemic-prone diseases. These labs are being supported by a contractual microbiologist to manage the laboratory. About 29 states (42 labs) have completed the procurement. In addition, a network of 12 laboratories has been developed for influenza surveillance in the country. In nine states, a referral lab network has been established by utilizing the existing 65 functional labs in medical colleges and various other major centres in the states and linking them with adjoining districts for providing diagnostic services for epidemic-prone diseases during outbreaks. Based on the experience gained, the plan will be implemented in the remaining 26 states/UTs. A total of 23 medical college labs, identified in Bihar, Assam, Odisha, Tripura, Kerala, Haryana, Jammu & Kashmir and Manipur, have been added to the network during 2012–13 to provide support in the adjoining districts.

Considering the non-availability of health professionals in the field of epidemiology, microbiology and entomology at district and state levels, MOHFW has approved the recruitment of trained professionals under NRHM to strengthen the disease surveillance and response system by placing one epidemiologist each at state/district headquarters, and one microbiologist and entomologist each at the state headquarters.

Figure11: Satellite Image and basic information: Cuttack

5. REVIEW OF EWS IN CUTTACK

5.1 GENERAL CITY INFORMATION

Cuttack is one of oldest cities of Orissa and was the state capital till 1950, before being shifted to Bhubaneswar, the present capital is only 35 km towards south. Cuttack city is located between 20° 30'N - 85° 50'E to 20° 5'N - 85° 83'E. and it has an average elevation of 36 meters (118 ft). Located at the apex of the Mahanadi delta, the city is surrounded by the river and its tributaries on almost all sides. Cuttack city is situated in between of two major rivers i.e. Mahanadi and Kathajodi.

Cuttack city is saucer-shaped in its geographical formation. In earlier times there were many ponds which use to retain & moderate storm water runoff into the drain. These ponds were eventually filled and became low lying areas with little scope for natural drainage. The Mahanadi provides much of the drinking water to the city. There are also numerous small ponds (also known as pokharis) in the city that store rain water. The river is also used as a dumping ground for sewage produced in the city. The city experiences a hot and humid climate in summer, a dry and cold climate in winter, with the most ideal climate experienced between mid-January to mid-March. The annual average rainfall varies from 1557.20 mm. During the south-west monsoon, the average wind speed is 15 kms per hour and it drops to only 5-10 kms per hour in October. The summer season is from March to June when the climate is hot and humid. Thunderstorms are common at the height of the summer.

The monsoon months are from July to October when the city receives most of its rainfall from the South West Monsoon. The winter season from November to February is characterized by mild temperatures and occasional showers. Temperatures may exceed 40°C at the height of summer and may fall to below 10°C in winter. As of 2011 India census, Cuttack had a population of 610,189. Males constituted 316,242 of the population and females 293,947. The city is subdivided into total 59 municipal wards.

5.2 BACKGROUND ON HAZARD RISK

The city of Cuttack is exposed to a range of natural hazards. However, city is highly exposed to hydro-meteorological hazards such as cyclones and floods due to its unique geo-climatic location along the eastern coast of India. The Bay of Bengal segment of the North Indian Ocean cyclone basin is highly prone to cyclonic events. Odisha, is one of most cyclone prone and storm surge hazard prone region in eastern India, because of its location (near the Tropic of Cancer), its flat coastal topography and high tidal range. These flooding events in the deltaic area of Orissa arise due to a highly complex and non-linear interaction of the storm surge, the tide, coastal bathymetric profile due to short period wind waves, normal river discharge and additional river discharge from the rivers swollen by heavy rain fall as well as direct flooding of the deltaic land by intense rainfall over several days.

The Cuttack city periodically experiences loss of life and severe damage from tropical cyclones originating in the Bay of Bengal (Murty et al., 1986; Dube et al., 1994, 1997, 2000a, b; Das et al., 1983). In the past, the other adjoining coastal districts of Cuttack have also experienced, severe flooding, not only due to storm surges originating in the Bay of Bengal, but also due to flooding of rivers and heavy precipitation associated with tropical cyclones and monsoon depressions.

Database on tropical cyclones in Odisha, analyzed for the period between 1877 and 2000, indicates 128 incidences of floods associated with tropical cyclones and monsoon depressions. Cuttack District ranks second with 20 cyclone landfalls and is preceded by Balasore District (with 22 landfalls). Based on the importance of the city in terms of its contribution to the local economy (religious and tourist center), risk to the populations is very high (Chittibabu et al., 2004).

The changing hydrological and ecological characteristics of the Cuttack city are also defined by its location on the eastern shoreline and southwestern edge of Mahanadi delta. The Mahanadi Delta where the city of Cuttack is located is regularly affected by tropical cyclones and floods of various intensities. These flood events arise due to a highly complex and non-linear interaction of storm surge, tides, and intense rainfall, ranging from several hours to several days, resulting in extraordinary discharge of rivers.

Orissa coast and interior areas often face heavy rainfall events associated with cyclones. These events, especially during late monsoon season (when dams are full) can lead to emergency release of water from dams. Emergency release of water from Hirakund dam upstream can also impact the city. Due to its location within the Mahanadi Delta, this city can be marooned for days in case of emergency water releases from Hirakund dam. Since the cyclone/depression related heavy rainfall events are common in the Mahanadi basin and Mahanadi is an interstate river, the dam management is a challenge.

Geophysical Hazard

Cuttack is comparatively safe from geophysical hazards. Historically, Odisha has experienced very few moderate earthquakes. Some events with magnitudes in excess of 5.0 have originated in the Bay of Bengal off the coast of the state. Several faults have been identified in the region and some have shown evidence of movement during the Holocene epoch. The Brahmani Fault in the vicinity of Bonaigarh is among then. The Mahanadi also flows through a graben structure. Several deep-seated faults are situated beneath the Mahanadi Delta. However, it is important to mention that proximity to faults does not necessarily translate into a higher hazard as compared to areas located further away, as damage from earthquakes depends on numerous factors such as subsurface geology as well as adherence to the building codes.

The vulnerability atlas of India published by Building Materials & Technology Promotion Council (BMTPC) of Govt. India, and Code of Practice (IS 1893:2002, Part 1) for Earthquake Resistant Design has divided India into four zones depending on the earthquake vulnerability of the area i.e. Zone- II, III, IV, and V. Zone II is Low Damage Risk Zone, Zone-III is Moderate Damage Risk Zone, Zone – IV is High Damage Risk Zone and Zone-V is Very High Damage Risk Zone.

The seismic hazard map of India was also updated in 2000 by the Bureau of Indian Standards (BIS). There are no major changes in the zones in Odisha with the exception of the merging of Zones I and II in the 1984 BIS map. Districts that lie in the Mahanadi river valley lie in Zone III, and within Odisha this zone stretches from Jharsuguda along the border with Chhattisgarh in a south-easterly direction towards the urban centers of Bhubaneswar and Cuttack on the Mahanadi Delta. Cuttack District lies in the Zone III.

Since the earthquake database in India is still incomplete, especially with regards to earthquakes prior to the historical period (before 1800 A.D.), these zones offer a rough guide of the earthquake hazard in any particular region and need to be regularly updated.

Hydro-Meteorological Hazards

The Bay of Bengal segment of the North Indian Ocean cyclone basin is highly prone to cyclonic events; however Arabian Sea is one of the least intense global cyclone basins, dominated by the monsoon and relatively infrequent severe cyclonic storms. State like Orissa, are the more cyclone and storm surge hazard prone states in western India, because of its location (along the Tropic of Cancer), its flat coastal topography, high tidal range and 480 km long coast line.

Odisha is always vulnerable to cyclones in April-May and September-November. Once every few decades a super cyclone strikes Odisha. Recent Super Cyclone that hit Odisha in the last Century were in 1942, 1971 and 1999. The Super Cyclone of 1999 killed about 10,000 and traumatized millions who survived its wrath. Over 15 million people were affected. Throughout India's massive coastline, there area 250 cyclone-warning sets, of which 34 are in Odisha, covering 480 Km of coastline. During Super Cyclone of 1999, 97 nos. of blocks and 28 ULBs and about 12569000 population were affected. The total agricultural land affected was 1733000 hectares with 9885 nos. of human casualties. Cuttack city situated in very high damage risk zone.

Cyclone Phailin

The Very Severe Cyclonic Storm (VSCS) Phailin originated from a remnant cyclonic circulation from the South China Sea. The cyclonic circulation lay as a low-pressure area over the Tenasserim coast on October 6, 2013. It subsequently moved over to the north Andaman Sea as a well-marked low pressure area on October 7. It concentrated into a depression over the same region on October 8 moving west-northwest wards, and then intensified into a deep depression on the morning of October 9 and further into a cyclonic storm (CS), 'Phailin' in the evening of the same day. Moving northwest wards, it further intensified into a severe cyclonic storm (SCS) in the morning of October 10 and into a VSCS in the forenoon of the same day over east central Bay of Bengal.

The VSCS Phailin crossed Odisha and the adjoining north Andhra Pradesh coast near Gopalpur (Odisha) around 2230 hours IST on October 12, 2013 with a sustained maximum surface wind speed of 200-210 kmph gusting up to 220 kmph. It caused very heavy rainfall over Odisha leading to floods and strong gale winds causing large scale structural damage and storm surges triggering widespread coastal inundation over Odisha.

The maximum rainfall occurred over the northeast sector of the system centre at the time of landfall. A maximum 24-hour cumulative rainfall of 38 cm has been reported over Banki in Cuttack district of Odisha. Based on the post-cyclone survey report, a maximum storm surge of 3.5 meters above the astronomical tide has been estimated in the low-lying areas of Ganjam district of Odisha in association with the cyclone and the in-land inundation of saline water extended upto about one kilometer from the coast.

Like many other cities and towns along the eastern coast of India, the city of Cuttack in Cuttack district is highly vulnerable to cyclones, extreme rainfall, flooding and drought like conditions. Even though its population is 610,189 (2011 census) the city is growing rapidly. The city is also an important religious and cultural center with tourism related services being the key economic driver. Cuttack also has more than 200 slum areas, mostly inhabited by wage workers. The Mahanadi bank where the city of Cuttack is located, is regularly affected by tropical cyclones and floods of various intensities. These flood events arise due to a highly complex and non-linear interaction of cyclones and intense rainfall, ranging from several hours to several days, resulting in extraordinary discharge of rivers. An analysis of the database on tropical cyclones in Odisha for the period 1877 – 2000 indicates the incidence of 128 flood events associated with tropical cyclones and monsoon depressions.

Tracks of the monsoon depressions from IMD cyclone e-atlas having genesis, 1.a) south of 20°N for the period 1950–1979, 1.b) south of 20°N for the period 1980–2009, 2.a) north of 20°N for the period 1950–1979, and 2.b) north of 20°N for the period 1980–2009. For this study the maps, and the relevant statistics, will be generated using the online Cyclone e-Atlas of the India Meteorological Department.

In Cuttack, rivers such as the Mahanadi, and its many tributaries and branches flowing through the city expose vast areas to floods. Damages are caused due to floods mainly in the Mahanadi, the Kathjori, and the Kuakhai. These rivers have a common delta where flood waters intermingle, and when in spate simultaneously, wreak considerable havoc. This problem becomes even more acute when floods coincide with high tide. Cuttack city is highly prone to floods which causes heavy loss to lives and property.

During every monsoon some of the areas such as Kazi Bazaar, Rover's Street, Stewertpatna, Mehendipur, Mansinghpatna, Professorpara, Gamhadia, Mahmadia Bazaar, Sutahat, Bidanasi, Deula Sahi, Roxy lane,Jhola Sahi and Khatbin Sahi Badambadi, Kesharpur, Raja Bagicha and Sheikh Bazar water logged.

One of the main reason in Cuttack city for flooding is its location, shape and the overbank flowing of water due to heavy rainfall at the upper end and catchment areas of the Mahanadi river. It depends upon the amount of water collected at the river course, the carrying capacity of the river, the river run off to the ocean at the mouth and the flow dynamics-morphological setting system. All the tributaries of Mahanadi rivers after flowing in the varied terrain attain their old stage in the coastal region of flat and low relief nature. They fall in the Bay of Bengal forming network of distributaries and varieties of landforms. Mahanadi river having vast catchment add huge amount of sediments to be deposited in the coastal basin to form the arcuate delta. Mahanadi and its distributaries most often cause flood in the low-level landforms like delta, peneplains and natural levees along with the adjacent areas of the entire river courses.

Heat Wave is defined as a condition of increased atmospheric temperature that leads to physiological stress, which sometimes can claim human life. Quantitatively Heat Wave can be defined as any increase from the normal temperature (i.e. 40° C). Again, depending on the upper deviation from the normal temperature it can be Moderate Heat Wave (40+5 or 6° C) or Severe Heat Wave (40+ 7° C or more). If the maximum temperature of any place continues to be 45° C for consecutive two days, it is called as a Heat Wave condition. Physiologically human body can tolerate environmental temperature till 37° C. Whenever the environmental temperature increases above 37° C, the human body starts gaining heat from the atmosphere. In the case of humidity being high along with high temperature, a person can suffer from heat stress disorders even with the temperature at 37° or 38° C. Higher daily peak temperatures and longer more intense. Heat Waves are becoming increasingly frequent globally due to climate change. Extreme heat events already have a significant impact in India. In the year 1998, the State of Odisha faced an unprecedented Heat Wave situation, as a result of which 2042 persons lost their lives. Though extensive awareness campaigns have largely reduced the number of casualties during post 1998 period, still a good number of casualties are being reported each year.

5.3 BRIEF VULNERABILITY PROFILE

The city and its urban infrastructure is highly vulnerable to incidences of hydro-meteorological events. Its saucer type shape, which makes it more vulnerable for floods and water logging. The interviews and subsequent field visits by the review team identified the vulnerability of the existing drains and the associated infrastructure in city. A majority of sewage systems present around the city's periphery are not designed to accommodate the recent development/expansion, which has taken place within the city over the last one decade. In addition, open drains pave way for accumulation of other wastes (e.g., plastics) which lead to blockage/bottlenecks leading to failure of the system.

The physical/locational vulnerabilities of the built infrastructure is also the reason for local disasters in events of modest daily rainfall, especially during the months of July and August.

5.4 INSTITUTIONAL FRAMEWORK

List of key agencies currently involved in the process of issuing early warning and coordinating response before and during the events, their roles and current functioning based on the available plans and conducted interviews are described below.

India Meteorological Department (IMD)

IMD receives information on rainfall and temperature from its 213 rain gauge stations, 37 automated weather stations and 117 automated rain gauge stations. These stations send their information to the national center in Pune to process the data and provide both regional and local weather information.

IMD currently provides now-cast information in the form of satellite imagery, model based on five days forecast for rainfall and temperature (maximum and minimum), and one day forecast for thunderstorm and wind. This forecast is provided two times in a day – morning and noon. During the monsoon months, in addition to the above forecasts, the centre also provides the catchment level rainfall, synoptic situation results, quantitative precipitation summary and heavy rainfall warning.

The uncertainty of these forecasts currently stands at 50 per cent, with efforts to improvement underway. The plan to install weather radars in Odisha is an attempt being made towards increasing the reliability of the forecast. Being the regional facility for cyclone forecast, the centre uses cyclone warning dissemination system for providing forecast for the region in general and state in specific. During the months from March to June, the centre also provides extreme temperature forecast and warning based on heat index (based on temperature and humidity).

IMD disseminates information directly to select government institutions, which include water resource department, education department, transportation department and health department. In addition, the centre also provides information directly to the local media to be published on a daily basis.

Central Water Commission (CWC)

CWC state office is situated in Bhubaneswar, provides inflow information during monsoon. This information is used by the Department of Water Resources to predict the possible reservoir levels, and is currently aiding them to manage the outflow from all dams within the state. The information provided is based on models that were developed at the time of construction of respective dams within the state. There is realization within the department that this forecast information will have to be improved taking into account the current situation, where there is evidence of change in the high flood levels due to sedimentation.

In event of possible flood or dam release/ overflow, CWC disseminates its forecast to select government departments that include Special Relief Commission, Officer (Engineer) In-Charge Flood Control Cell Water Resource Department, Revenue Control Room, Sub Collector and Irrigation Department.

Odisha State Disaster Management Authority (OSDMA)

The Government of Odisha set up Odisha State Disaster Mitigation Authority (OSDMA), as an autonomous organization in the intermediate aftermath of the super cyclone of 1999. It was registered under the Societies Registration Act, as a non-profit making and charitable institution for the interest of the people of Odisha, with its headquarters at Bhubaneswar and jurisdiction over the whole state.

OSDMA has the mandate of taking up the mitigation, relief, restoration, reconstruction activities and of coordinating with bilateral and multi-lateral agencies post event. The agency, during peacetime, is involved in developing technical documents related to disaster management and also in providing training to government and other stakeholders.

The State Emergency Operations Centre (SEOC) coordinates with OSDMA and provides support to other disaster management agencies (city and state). It is currently operational 24X7. This centre, under the revenue department, acts more as a coordinating authority in the event of a major disaster.

The OSDMA and SEOC have their mandate to function post disaster. They too disseminate warning information about extreme events to key nodal agencies at district/state levels.

The Collector/District Magistrate (DM), Cuttack is the head of the district disaster management cell. The DM is in-charge of disseminating warning and coordination disaster events that scale beyond the Cuttack city boundary.

OSDMA is currently supporting all key departments in their preparation of disaster management plan. This is expected to provide key information about the functioning and planning of the respective departments, and may help both the DM and Municipal Commissioner in coordinating with the departments before an extreme event and contain the disaster.

Flood Control Cell, Water Resource Department

Flood control cell within the Water Resource Department (WRD) is the nodal agency for analyzing the situation across all river basins in Odisha during the monsoon and at the time of cyclones. The flood control cell is functional 24x7 during the monsoon period and provides a daily bulletin on the flood and flood-like situation across the state. This bulletin uses the information provided by the IMD to make forecast on the reservoir level and possible flood situation.

WRD provides warning/report daily at 5:30 p.m. on the situation of flood (daily flood bulletin), status of river gauges, status of river discharge, status of major reservoirs, forecast of rainfall (based on IMD data), average travel time of flood water and nowcast of cloud cover (based on IMD imagery). The department disseminates warning to more than 72 government agencies within the state through fax and to media through daily briefing. The reports and warnings generated by the flood cell are also available online for public access. WRD depends upon the State and City Emergency Operation Centre for translating and providing general warning to the public.

Integrated Disease Surveillance Programme (IDSP) Unit, Department of Health and Family Welfare

The Department of Health and Family Welfare monitors the health situation across the state for signs of epidemic. The department is also the nodal agency and houses the state surveillance unit of Integrated Disease Surveillance Programme (IDSP) across the state. The IDSP monitors key diseases through active and passive surveillance. The active or the syndromic surveillance is currently done by health workers surveying door–to-door and reporting disease incidences periodically (weekly). Passive surveillance is carried out through evidence of diseases recorded and reported by doctors from Capital Hospital. While the surveillance methodology is robust (in districts), the information currently collected for the city is little to take timely action. Also, reporting of cases (passive surveillance) is currently not being done by private hospitals. Currently, the reporting is only done by Capital Hospital, which is a government hospital. The use of technology by field level health workers is limited to paper-based forms, which are collated weekly, which make it difficult to take timely action. Nevertheless, there exists strong coordination of the department with the Health Department, Municipal Corporation, to initiate actions such as spraying and fumigation at the first sign of outbreak of vector-borne diseases. The information collected by this department is currently disseminated to the Health Department, Municipal Corporation, and the national center, IDSP.

District Collector Office

District collector office of Cuttack district plays a very crucial role in early warning to city. It has a District Emergency Operation Center (DEOC) in its premises, which is headed by Deputy Collector (Emergency), Cuttack District. DEOC is well equipped with basic equipment's for disaster management. This office also prepared District Disaster Management (DM) plan and it is updated for year 2016-17.

Chief District Medical Office (CDMO)

CDMO, Cuttack, is responsible for public health issues in entire district including health advisories. The CDMO, with support from various health agencies, coordinates, direct and integrate city level response including activation of medical personnel, supplies and equipment, contain outbreak of epidemics and coordinate with CMC in their activities.

5.5 INDICATORS OF THE EXISTING CONDITION OF EWS

Table 4: Criteria development matrix: Indicators of existing condition of EWS in Cuttack

S. NO.	COMPONENT 1	EWS GOVERNANCE - CITY LEVEL INSTITUTIONAL FRAMEWORK					
	CRITERIA	DEVELOPMENT STAGE INDICATORS					REMARKS
		1	2	3	4	5	
1.1	State legislation for EWS framework includes local authority (urban local body) as an integral part (document, control ULB)	●	●	●	●	○	Odisha State have it's State DM Policy and State Disaster Management Plan. The State DM Plan mentions about Early Warning to District. The State Plan does not highlight ULB role as a part of EWS. ULB is working on updated DM Plan for Cuttack city.
1.2	Institutional mechanism for local authority (ULB) is an integral part of EWS framework (document, mandate, implementation)	●	●	○	○	○	There is currently no separate institutional mechanism within urban local body. Also, there is no updated City Disaster Management Plan of Cuttack city.
1.3	ULB accorded with the authority to dis-seminate warnings (mandate, SOP, imple-mentation)	●	●	○	○	○	The city administration realizes the need. However, warning dissemination rights lies with district administration.
1.4	Extent of preparedness and prevention actions evident among state technical and disaster management agencies (relevant department DM Plan at state, SOPs, link from state to city)	●	○	○	○	○	Preparedness and prevention actions were evident among state, district and city level agencies for hydro-met (floods, cyclone, heat waves) and public health hazard risks. Select department have DM plan but they are yet to implement the same.

S. NO.	COMPONENT 2	USER NEEDS					
	CRITERIA	DEVELOPMENT STAGE INDICATORS					REMARKS
		1	2	3	4	5	
2.1	Hotspots identified for potential hazard impact (identified, mapped and updated)	●	●	○	○	○	Institutional memory of hotspots exists based on historical events especially floods and disease prevalence. Authorities indicated that maps demarcating the vulnerable / risk prone areas are being prepared. NDRF/ODRAF and other key stakeholders also indicated the need for such maps.
2.2	Outreach practice (dissemination of warning)	●	●	○	○	○	Forecast exists for weather events, warning exists for all hydro-met hazards and heat wave. Information is provided by IMD, Bhubaneshwar and health department to government institutions (at state and district level) and media (print and electronic). Warning for other key hazards especially vector borne and water borne diseases are yet to be designed.
2.3	Timely dissemination of warnings to vulnerable groups (residing in slums, high risk prone areas)	●	●	●	○	○	District level agencies plays very crucial role in timely dissemination of warnings to vulnerable groups. Warning of disease outbreak is provided to slums through IDSP under CDMO. The state government and city administration receive advance warning and notification in the events of cyclone. For other hazards strategy for dissemination of warning needs strengthening
2.4	Arrangement for night time warning (limited to floods, landslides, cyclones, tsunamis)	●	●	●	○	○	Night time warning for hydro-met hazards is in place. Floating devices with warning signals have been distributed by the OSDMA for this purpose.
2.5	Media engagement in dissemination of warning	●	●	●	○	○	At state level, media collects hydro-met warning information from IMD (at designated time only in day), Department of Water Resources, Health Department and IDSP on a regular basis and from OSDMA, in case of extreme events. The information is presented by media with limited value additions such as publish in local language. Local media use similar information and display or publish.
2.6	Content of warning to general public by local government (ULB) (graphic representation and behavioural content for taking actions at individual/household and community levels)	●	●	●	○	○	CMC (Cuttack Municipal Corporation) doesn't provide any warning to general public in city. District administration and Health department (including IDSP Cell), currently provides hydro-met and health warning. However, CMC provides advisories to its citizens including do's and don'ts.

S. NO.	COMPONENT 3	OPERATIONAL COMPONENTS OF EWS					
	CRITERIA	DEVELOPMENT STAGE INDICATORS					REMARKS
		1	2	3	4	5	
TECHNICAL AGENCIES							
3.1	Risk assessment and integration with potential impact assessment (identification, mapping, integration)	●	●	○	○	○	The city level hazard, risk and vulnerability assessment (HVRA) for Cuttack City was underway during review. Water resource department (Govt. of Odisha) also working on a project to establish early warning system for Mahanadi river basin from Hirakund dam till coast. Department also plan to map inundation for Cuttack city.
3.2.1	Warning mechanism for geophysical hazards (earthquake)	●	○	○	○	○	The city of Cuttack is not affected to Tsunami and Landslides.
3.2.2	Warning mechanism for hydro-meteorological hazards (cyclone, severe winds, heat wave, cold wave, extreme rainfall, fluvial flooding, pluvial flooding)	●	●	●	●	○	Advanced warning protocol with adequate respite time exists. IMD is in the process of testing Doppler radar at Gopalrpur and Paradip in Odisha. Doppler radar at Met Centre in Bhubaneshwar will also be made available to relevant stakeholders soon. There is consistency in warning message and adequate respite time for cyclone, heat wave and cold wave, while inadequate respite time is available for severe winds, extreme rainfall and fluvial flooding. IMD, Bhubaneswar, being the regional centre for cyclone monitoring in India, is able to forecast and provide warning. Impacts including precautionary measures (action points) are provided for heat and cold waves. General public is able to understand and translate the warning within its functioning. Impact of severe winds is not presented for general public to understand/take action. Warnings of extreme rainfall and fluvial flooding are provided by IMD and CWC at regional scale, with support from Water Resource Department. Non-availability of information regarding the local impact in and around Cuttack city reduces the respite time.
3.2.3	Advisory mechanism for public health risks (vector-borne and water-borne diseases)	●	●	●	○	○	Warning provided by CDMO of health department and IDSP upon the realization of disease breakout.
3.3.1	Availability of technology to nowcast/ forecast geophysical hazards by technical agencies	●	○	○	○	○	Technology to nowcast being implemented by IMD, with limited respite time.
3.3.2	Availability of technology in nowcast/forecast of hydro-meteorological hazards by technical agencies	●	●	○	○	○	Advanced technology have been used to forecast and nowcast hazard, which is being implemented by IMD for hydro-meteorological hazards. Advanced products through NWP (QPF) have been used by IMD for nowcast / forecast. The city will still require additional technology such as AWS and River Guages to downscale the impacts.
3.3.3	Disease surveillance system (surveillance coverage, collection method, analysis)	●	○	○	○	○	Monitoring of health information at district level is being carried out by CDMO and IDSP Cell and at city level by Health Department, Municipal Corporation. Technology to address city-specific needs is currently limited.
3.4	Uncertainty in forecast and warning (hydro-met, public health)	●	●	●	●	○	Forecast is given by IMD and warning is provided by both IMD and Flood Control Cell (Water Resource Department) to all government institutions and media. The forecast of IMD is used for enhancing the forecast provided by the Flood Control Department. OSDMA and EOC get involved in case of large-scale hydro-met events, especially cyclones. For public, health forecasting mechanism is not in place. Warnings are provided upon realization of first outbreak by IDSP and Health Department, Municipal Corporation, through media.

S. NO.	COMPONENT 3	OPERATIONAL COMPONENTS OF EWS					
	CRITERIA	DEVELOPMENT STAGE INDICATORS					REMARKS
		1	2	3	4	5	
DISASTER MANAGEMENT AGENCY / LOCAL AUTHORITY (ULB)							
3.5	Budget allocation by the local authority for EWS	●	●	○	○	○	There is no evidence of realization.
3.6	Data availability for operations of EWS	●	○	○	○	○	State government installed weather stations in entire state at block level. OSDMA has also made attempts to collate weather data. ULB also realised the need of local data but currently there are no active projects for information collection or collation at city level.
3.7	Staffing and capacity within local authority for operation and maintenance of EWS	●	●	○	○	○	Currently the local authority provides only health advisories. Therefore, the realization of need for dedicated staff for EWS is not evident.
3.8	Use of modern technology to disseminate warning (hydro-met, public health)	●	●	○	○	○	The Cuttack city will not be directly affected by landslide or tsunami. There is no warning mechanism established for earthquake to be disseminated. To disseminate hydro-met warning, district administration uses generic media such as newspapers, local cable channel and radio. Health advisories are generally provided to the public at large through local newspapers and television.
3.9	Redundancy (multi-mode) in communication networks	●	●	●	○	○	Recognition of the need is evident within the technical institutions and state authorities only.
3.10	City Emergency Operations Centre (EOC) for housing data of hazard, vulnerability and risk	●	●	○	○	○	The district EOC is located within the city, and is realized to function for the district and the city. Due to their presence and operation, there is no realization of need by the ULB or other technical institutions to establish a city EOC. During the time of evaluation, UNDP was supporting the city towards the development of hazard, vulnerability and risk atlas.

S. NO.	COMPONENT 4	PRODUCTS AND SERVICES ACROSS THE WARNING CHAIN					
	CRITERIA	DEVELOPMENT STAGE INDICATORS					REMARKS
		1	2	3	4	5	
4.1	Degree of local details incorporated in warnings	●	●	○	○	○	This exists only for hydro-met and public health.
4.2	Raisng awarenss about warnings at city level	●	●	○	○	○	Awareness programs are currently conducted by OSDMA, UNDP and IDSP.
4.3	Ability of technical agencies and disaster management institutions to cater their early warning products and services to user-specific requirements	●	○	○	○	○	User needs assessment has not been undertaken. But the stakeholders realize the for specific products especially to address hydro-met and public health risks.
4.4	Risk communication	●	●	○	○	○	The city level hazard, risk and vulnerability assessment (HVRA) for Cuttack City was underway during review. The information generated by the technical agencies communicates hazard information and not vulnerability information to government agencies and media. The key stakeholders, based on their previous experience, do tend to translate the hazard information to possible risk (including vulnerability) information to take action.

S. NO.	COMPONENT 5						COORDINATION MECHANISM
	CRITERIA	DEVELOPMENT STAGE INDICATORS					REMARKS
		1	2	3	4	5	
5.1	Extent of coordination between technical agencies and disaster management agencies	●	●	●	○	○	Due to absence of city disaster management cell and city EOC, the district agencies (DDMA and district EOC) plays a very significant role in ensuring coordination. While their mandate limits their extent of involvement in city affairs, being a district agency provides them with an advantage to link and communicate with all agencies.
5.2	Extent of links between disaster management agencies and service providers	●	●	●	○	○	Formal linkages between agencies is evident through e-mail, fax and phone communications. (CMC - DDMA/DEOC - OSDMA/SRC - IMD/CWC)
5.3	Extent of links between media and disaster management agencies	●	●	●	○	○	Reflection of warning information in media products are evident (daily) especially for hydro-met events such as cyclone and heat waves. Linkages between media and technical agencies were found to be more strong through their frequency of interaction in comparison to the disaster management agency. Media also report on public health risks such as vector borne and water borne diseases based on investigation of their own.

S. NO.	COMPONENT 6						SERVICE DELIVERY AND FEEDBACK LOOPS
	CRITERIA	DEVELOPMENT STAGE INDICATORS					REMARKS
		1	2	3	4	5	
6.1	The knowledge of user community of early warning system and its effectiveness	●	●	●	●	○	ULB is well aware of the warning. Co-ordinated actions was evident especially for cyclone and heat.
6.2	Extent to which the warning mechanism allows for feedback from the affected area	●	●	●	○	○	Limited feedback mechanism exists from affected area (from block level to district).
6.3	Level of reflection and learning evident within local authority	●	●	●	○	○	Cuttack city administration is well experienced due to the recent events including Cyclone Phalin and Cyclone Hudhud which had an impact on the district. In addition, the administration is also active towards providing advisories related to heat waves and are also geared towards taking measures to minimize the impact.
6.4	Monitoring, evaluation and targets for improvement of EWS	●	●	●	○	○	Performance of the early warning system for hydro-met hazards is being monitored and targets for improvement is under way.

5.6 SUMMARY

Cuttack city is very close to the capital city Bhubaneshwar. Bhubaneshwar has advantage of being the state headquarters of all key State Government and regional institutions such as Odisha State Disaster Management Authority (OSDMA), the State Emergency Operation Centre (SEOC), Department of Water Resources (DoWR), Indian Meteorological Department's (IMD) Centre for Cyclone Warning, Central Water Commission (CWC) and State Surveillance Unit (SSU) of Integrated Disease Surveillance System (IDSP).

The city municipality is in process to update its city disaster management plan. Cuttack district have a comprehensive District Disaster Management Plan (DDMP) document, which has indication of local authority is a part of information collection, preparedness and generating awareness. However, it does not mention the need of early warning system or possible coordination required for collection and dissemination of early warning information, which is currently being issued by various authorities within the city.

Post major disaster events in Odisha, notably the super cyclone and heat wave of 1999, have resulted in increased awareness of the need for warning within the state. The events have led key technical agencies to focus on the development of state wide warning system. Bhubaneswar, being around 55 km from the coast of Bay of Bengal, and the distributaries of Mahanadi flowing near peri-urban areas, has attracted less attention from technical agencies for developing a city-specific early warning system. Nevertheless, there was evidence of forecast being developed for weather events and warnings being provided for all key hazards (excluding earthquake and landslide) by IMD, Water Resource Department and Health Department to other government institutions and media.

The review of key agencies brought to the forefront realization of need for early warning system for all hazards. Success of any EWS will depend on the detailed understanding of city risks. In case of Bhubaneswar, city-level risk assessment has been undertaken and the qualitative ward-level hazard indication has been mapped. This information is rudimentary and cannot be used for potential impact assessment or warning to vulnerable population in the city. The need of targeting the warning to the intended users is currently realized based on the experience and outcome of past disaster events. Technical institutions realize the gap in data collection for arriving at informed forecast for disseminating timely warning. For example, IMD indicated its requirement for high resolution city-specific radar information to track extreme rainfall events, while Water Resource Department indicated its requirement of high resolution satellite-based rainfall information to derive runoff within sub-basin and forecast water levels in the reservoirs. While individual technical and disaster management agencies realize their needs and share their forecast information through mail, phone and fax, no immediate plans exists within these agencies to develop forecast that could address the specific needs of other users.

IMD, Bhubaneswar, is the regional centre for cyclone monitoring in India. They currently forecast regional weather and also provide warning for cyclones. Based on their weather forecast, while some of the hazards, especially heat wave and their impacts, are being appreciated by the general public who are able to take action, events such as strong winds and heavy rainfall remain vague and no actions are being taken at the local level (ward-level flooding). The event of heavy rainfall provided at regional level is also less used by the Water Resource Department to incorporate into its functioning, especially reservoir management, due to high uncertainty and generalization of such forecasts. Similarly, Water Resource Department, being a state department, does issue flood warning at catchment level which is more relevant for district-level actions and irrigation, but does not convey city-level warning or impact.

Health advisories are currently provided by health department and IDSP, upon the realization of disease break out. Similar to hydro-met events, technology used to monitor, nowcast and disseminate warning lacks required information to address city-specific needs.

The current method of dissemination of warning by all the above agencies is through formal mail/ fax being sent to government departments. The same information is also disseminated to general public and local media, both print and television. In spite of the uncertainty in information, some of the government departments and technical agencies are able to interpret the information to suit their functioning requirements, while the general public is unable to translate the forecast into warning or actionable points. Addressing the last mile connectivity is still an issue.

Similar to IMD, Water Resource Department and IDSP, the state EOC is also located within the city. The strong presence of regional and state institutions has led to non-realization of needs to establish and operate a city disaster management centre with a functional city EOC. This has led to state institutions, including EOC, to function for the state and the city. Also, OSDMA, in spite of being a state authority, due to its presence in the city, has made attempts to collate data. ULB is currently not involved in the process of collection or collation.

Evidence of warning mechanism exists for hydro-met and public health risks. The key stakeholders, based on their previous experience, do tend to translate the hazard information to possible risk (including vulnerability) to take action. The agencies which are currently providing these warnings realize the need for development of customized products/services. The lack of user need assessment across all stakeholders may be the reason for isolated technology incorporation, product development and service delivery plans. While the awareness programmes are currently being conducted by state and national agencies (OSDMA, UNDP and IDSP) with a wide reach, the realization and move towards city-specific risk and warning issues are yet to evolve.

Due to the absence of Cuttack city disaster management cell and city EOC, the district and state agencies (OSDMA and EOC) wear more than one hat. While their mandate limits their extent of involvement in city affairs, being a state agency provides them with an advantage to link/communicate with all agencies. Formal links between agencies is evident through mail, fax and phone communications and in the reflection of warning information in media products (daily).

Post-event reflections leading to increased communication and response mechanism over the past one decade is evident from the emergence of new state institutions, decrease in the number of deaths and in timely transfer of information between departments (IMD sends a daily forecast at 12:30 p.m., while Water Resource Department sends a revised bulletin based on IMD forecasts at 05:30 p.m.). These warning messages are sent to all key government departments, including the media. But this system caters to only hydro-met hazards, especially those that are of importance to the state. City-specific forecast and warning is limited for events such as pluvial floods and disease incidents which occur every year. The need for development of a system is realized by all institutions.

It is important at this stage to note that EWS in the Cuttack City needs to be upgraded significantly to meet the larger objective of reducing fatalities and protecting infrastructure/assets from future events. It is recognized globally that an operational EWS has the potential of minimizing loss and contributing to sustainable development and building resilience. While technology is available for establishing the robust communication system for EWS, it is the institutional foundation and the networking arrangements which have to be deep rooted for meeting the desired objectives of the system. All the key elements of the system have to be functional and it is important to review them annually by targeting for different scenarios and measuring performance.

This report provides insights to issues that need to be addressed for an operational EWS, defines the criteria and measures the development stage indicators for the present situation. The results of this review provide a status and the need to be aware of key design considerations for improvement of existing EWS, as well as for design and implementation of new EWS. It is envisaged that city landscape will have to tailor solutions for public safety, and EWS will be designed and developed on various platforms. It is important to keep these systems people-centric and subsequently build risk knowledge among the stakeholders for success of this system. Criteria Development Matrix can be used as a tool for further review. As EWS systems develop in the city, robust EWS audit mechanism can be rolled in the future to measure system efficiency.

Figure 12 represents preparedness of EWS indicators for Cuttack city.

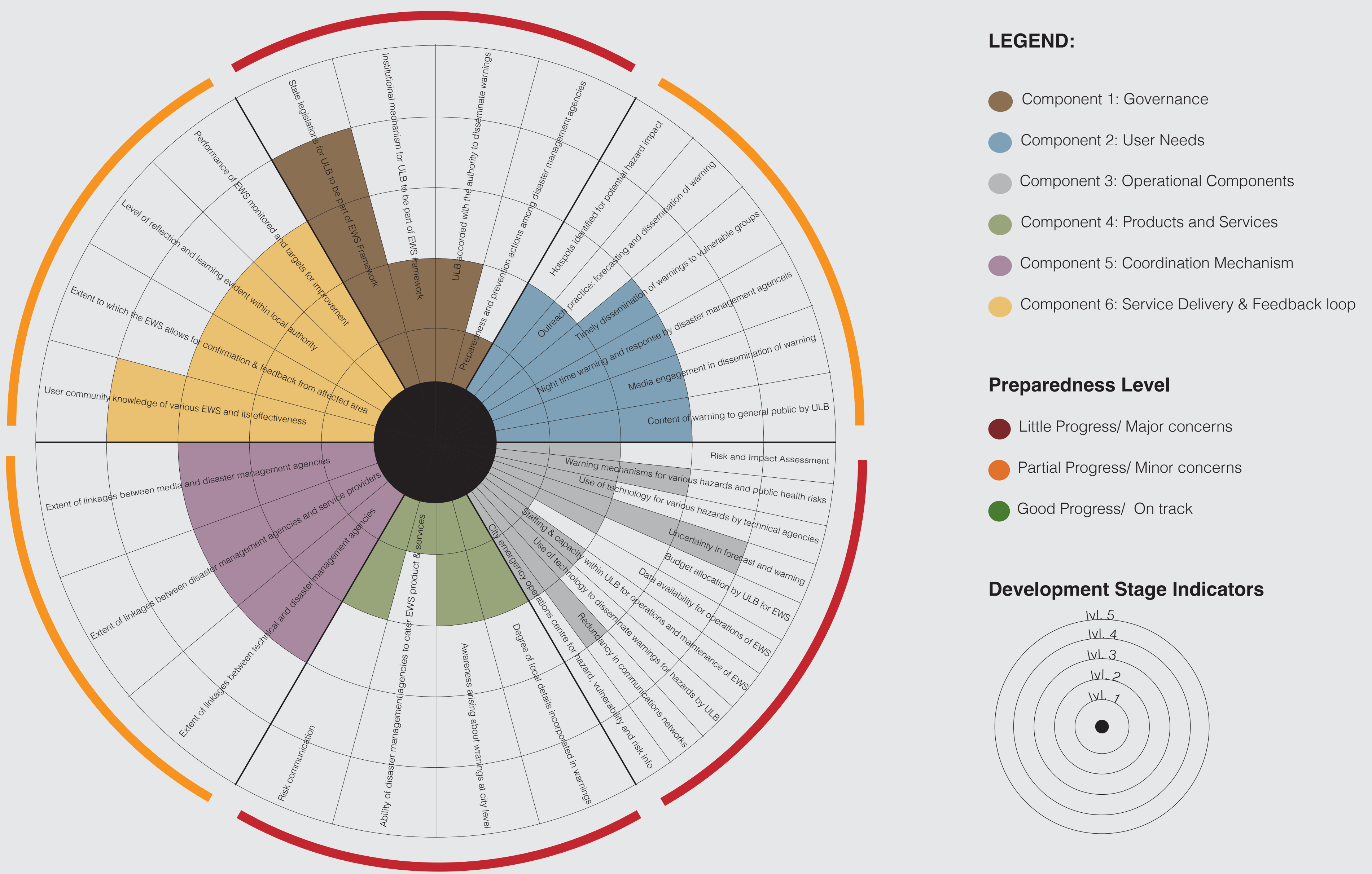


Figure 12: Preparedness of EWS indicators for Cuttack

6. CITY LEVEL EARLY WARNING SYSTEM OPTIONS FOR CUTTACK

City level multi hazard early warning system options are the initiatives which can help local and provincial and national agencies in staying well-prepared to cope with disasters, if the city or district administration incorporated them as a part of their future plans. These actions can act as road maps for city and district level decision makers.

- Increasing the disaster-facing capacity/ preparedness: Disaster management plan with risk reduction plans, disaster preparedness and mitigation actions for post-disaster situation.
- Robust infrastructure for risk reduction: Infrastructure development considering the risk factors of natural and manmade disasters.
- Comprehensive coordinated institutional system: Capacity building at the institutional level for comprehensive and well-coordinated administration during emergency situations.
- Community-level awareness and participation: Risk awareness programmes at the community-level and warning systems for better communication.

The actions are at different scales, broadly divided at regional and city levels and are described with the objectives, scoping, timeline, the importance of disaster risk preparedness and similar current actions and the line departments for the actions. Regional actions can be implemented as a common practice for all three towns whereas the city-level projects are dedicated to the specific issues and needs of the towns. City-specific risk resilient actions are indicated along with the priorities that need to be addressed along with their respective action descriptions.

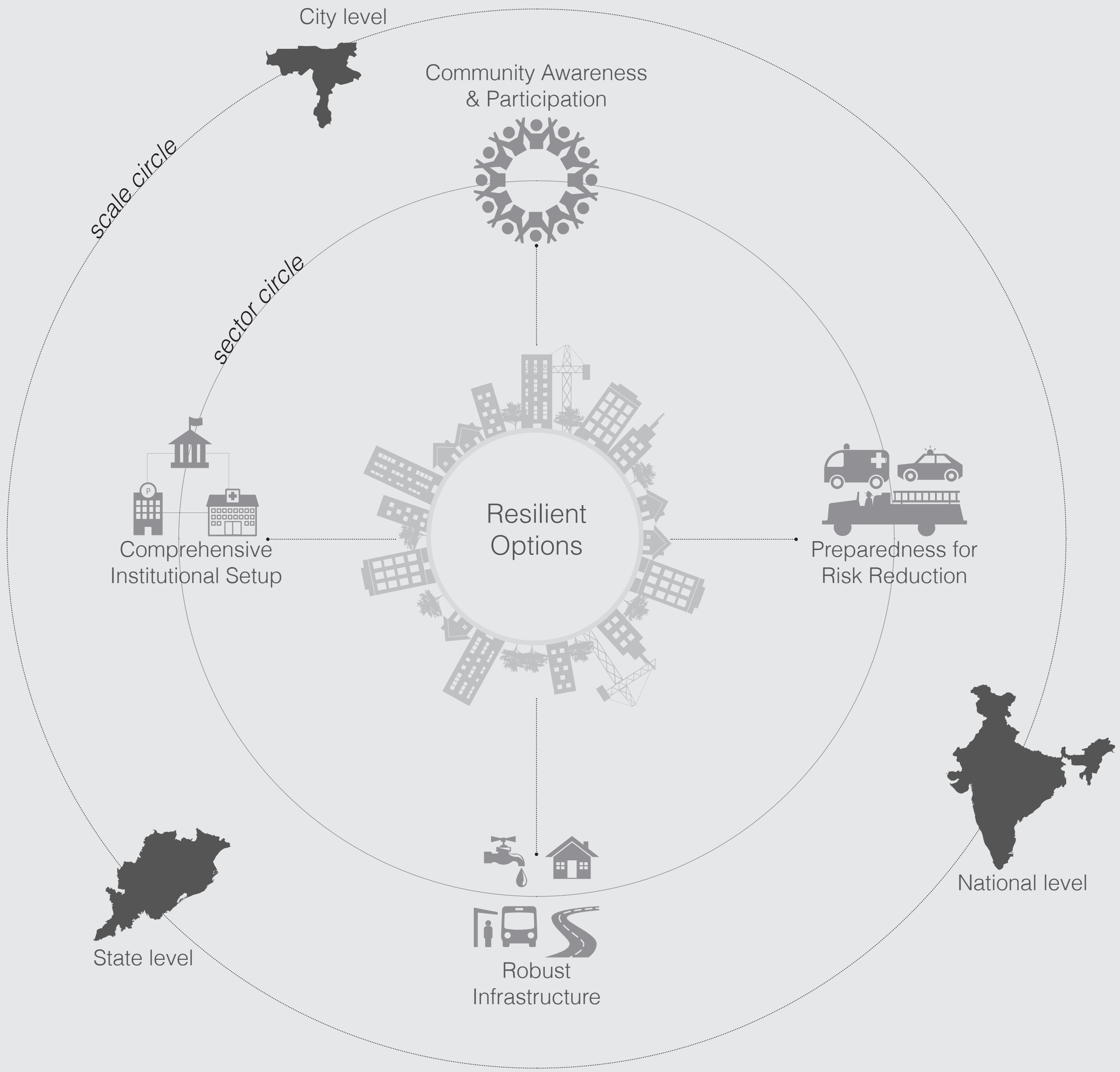


Figure 13: Resilient Option Framework

Action: 1	Multi Hazard Early Warning System Framework
Sector	Preparedness for Risk Reduction
Objective	To have a city-level ordinance to address and mainstream hydro-meteorological, geo-physical and climate change risk in the overall development and sector/department operations (especially around critical services).
Timeline	2017-2018
Brief	• To include disaster risk management/ mitigation in all upcoming plans, projects and programmes. • Maintenance – repair and renovation of the critical infrastructure. • Climate variability and risk is increasing day-by-day as the frequency of extreme events has high degree of impact among the growing population. Infrastructure development should be in such a way that there is minimum damage physically and there exists continuity of critical services in events of disaster. • Capacity building at the institutional level should include skills building for better responsiveness during emergency situations.
Owner	Cuttack Municipal Corporation
Supporter	Odisha State Disaster Management Authority District Collector of Cuttack Department of Housing and Urban Development, Government of Odisha
Current Scenario	Urban and infrastructure development and expansion of the towns is haphazard. There are no building norms followed in new building constructions. Roads and bridges do not have constant safeguard mechanisms such as grabbing walls or retaining walls. Basic amenities, such as water supply and electricity supply, are unplanned, which may be dysfunctional in post-disaster situations. There is very limited scope of disaster management in the planning and development practices.
Benefits	• City level institutions and development will consider the disaster management and EWS aspect, which will lead to a resilient urban system with higher capacity to cope with sudden, natural or manmade disasters.

Action: 2	Flood Resilience Measures (Structural and Non-structural)
Sector	Preparedness for Risk Reduction
Objective	To adapt structural and non-structural flood resilience measures for Cuttack city.
Timeline	2017–2020
Brief	• To have protective structures at the banks of river. • Structural protection measures include block ramps, opening of river beds, spurs, debris flow breakers. Structural measures should have little impact on the existing natural environment and avoid interfering with the current landscape. • Increased river management practices include maintaining vegetation along the river, excavation of sediment retention structures, repair of damage to protective structures, maintenance of river beds and banks. • The protection measures include creation of check dams and increased plantation along the natural drains to reduce the rate of flow and increase the rate of infiltration.
Owner	Cuttack Municipal Corporation
Supporter	Odisha State Disaster Management Authority District Collector of Cuttack Department of Water Resource, Government of Odisha Department of Housing and Urban Development, Government of Odisha
Current Scenario	Cuttack town is situated very close to Mahanadi and Kathjodi River. The town has, in the past, experienced several floods and the recent one was event which occurred in 2012. The impact was felt across the city when more than half of the population was isolated and could not move outside the town for more than three days due to heavy flow in the river.
Benefits	• Reduction in loss and damage due to extreme rainfall including flash flood. • Better management of natural resources including natural drainage and river basin management.

Action: 3	End-to-End Early Warning System for Floods in Mahanadi and Cuttack City
Sector	Preparedness for Risk Reduction
Objective	The main objective of this project is to reduce the intensity of floods and resultant flood damage to Cuttack city through: • Improved Reservoir operation to minimize peak floods, • Better preparation of institutions and society to handle flood emergencies
Timeline	2017-2020
Brief	Empower individuals communities and administration, threatened by natural hazards, to act in sufficient time and in an appropriate manner so that reduce the possibility of personal injury, loss of life and damage to property, or nearby and fragile environments". Elements of effective and complete End-to-End Early Warning System: • Risk knowledge, • Technical monitoring, risk assessment and warning, • Dissemination & communication of meaningful warnings to those at risk, • Response capability public awareness and preparedness to act.
Owner	Cuttack Municipal Corporation
Supporter	Odisha State Disaster Management Authority District Collector of Cuttack Department of Water Resource, Government of Odisha Centre Water Commission
Current Scenario	In Cuttack, rivers such as the Mahanadi, and its many tributaries and branches flowing through the city expose vast areas to floods. Damages are caused due to floods mainly in the Mahanadi, the Kathjori, and the Kuakhai. These rivers have a common delta where flood waters intermingle, and when in spate simultaneously, wreak considerable havoc. This problem becomes even more acute when floods coincide with high tide. Cuttack city is highly prone to floods which causes heavy loss to lives and property. During every monsoon some of the areas such as Kazi Bazaar, Rover's Street, Stewertpatna, Mehendipur, Mansinghpatna, Professorpara, Gamhadia, Mahmadia Bazaar, Sutahat, Bidanasi, Deula Sahi, Roxy lane,Jhola Sahi and Khatbin Sahi Badambadi, Kesharpur, Raja Bagicha and Sheikh Bazar water logged.
Benefits	• Increase respite time, • Provides timely and effective information on flood hazard, • Can reduce hazard intensity (by controlled release from dam), • Reduce magnitude of disaster (timely evacuation, preparedness), • Support city and district administration to prepare for effective last mile response well in advance.

Action: 4	SMS Based Advisories and Alert System for Tourists
Sector	Community Awareness and Participation
Objective	To make tourists informed of risk-prone areas and actions to be taken in events of disaster.
Timeline	2017–2020
Brief	• Basic disaster profile of the region through the tourism department to make outsiders aware. • Helpline numbers of emergency services and contact numbers of respective personnel for coordination and information. • Basic risk and preparedness information (healthcare and first aid) for tourists. This should include critical roads and places on the tourism maps to help generate awareness of possible risks • Prepare a 'Dos and Don'ts' list for emergency situations, especially in the forest areas and in events of extreme weather.
Owner	Cuttack Municipal Corporation
Supporter	Department of Tourism, Government of Odisha District Collector of Cuttack
Current Scenario	Tourists need to be well-informed, since they are more vulnerable as outsiders. The tourism department is active, but it does not have limited awareness of disaster preparedness.
Benefits	• Better coordination between tourism department and disaster management cell. • Enhanced risk awareness and preparedness among the tourists. • Increases safety and security to tourists and lowers their impact in events of disaster.

Action: 5	Guidelines for restricted or no-development zones in the city
Sector	Preparedness for Risk Reduction | Awareness & Capacity Building
Objective	To involve the communities in the city development process and include them in the vulnerability assessment process.
Timeline	2017-2020
Brief	• Community-level feedback for new development plans can help in addressing some of the local and regional issues. • Developmental needs and challenges can be sourced from residents through the use of mobile and web platforms to increase reach using limited resources. • Demand assessment of infrastructure development can create ownership among the community. • Involving academic institutions, especially schools and colleges through city development workshops can enhance the city resilience plan. • Awareness of building norms at the community level can help in promoting safe buildings
Owner	Cuttack Municipal Corporation
Supporter	Odisha State Disaster Management Authority District Collector of Cuttack Department of Housing and Urban Development, Government of Odisha Cuttack Development Authority
Current Scenario	There is currently no coordination between the administrative departments and the community in issues pertaining to new development strategies and plans.
Benefits	• Citizens will be aware of the upcoming development and services. • Citizens will have knowledge of the roles and responsibilities of different administrative and service providing departments. • Development will be based on the need of the people taking into consideration their shocks and stress. • Increased ownership among the community towards public infrastructure.

Action: 6	Provision for Night Time Disaster Warning
Sector	Preparedness for Risk Reduction
Objective	To establish night time disaster warning and response system.
Timeline	2017–2018
Brief	• On-site trained night staff for all critical institutions such as hospital, police, emergency control room, DC office and fire safety department. • Well-maintained street lights, preferably alternative backup plan of power supply to cater to interruptions during emergency situations. • Light reflective road infrastructures and signage. • Night time patrolling and ranging especially for forest fire vulnerable areas. • Siren or alarm system with speakers located at critical assembly points to communicate to people. • Toll free helpline numbers for emergency situations, alert notifications and developing an anytime responsive system.
Owner	Cuttack Municipal Corporation
Supporter	Odisha State Disaster Management Authority District Collector of Cuttack Superintendent of Police of Cuttack Fire Service, Home Gaurds and Civil Defence Cheif District Medical Officer Department of Housing and Urban Development, Government of Odisha
Current Scenario	There is no rescue plan available for night time warning and rescue. Signages are absent within the cities. There exists no public-address system or search and rescue equipment for night time operations. Currently, the condition of street lights is well-maintained in the main town areas, such as market areas. The outer areas and newly-developed areas need to have better lights and plans for night time rescue. Many of the institutions also do not back up power supply.
Benefits	• Easy operational rescue plan for night time emergency management. • Better coordination with community. • Increase the response time of first responders.

Action: 7	Institutional Quick Response Practice (QRP)
Sector	Comprehensive Institutional Set-up
Objective	To have an emergency response plan with easy-to-refer maps, predefined routes and tasks for the line departments to reduce the response time during disasters.
Timeline	2017-2018
Brief	• For easy and fast communication and networking among the line departments at town-level, such as WhatsApp groups, monthly meetings need to be initiated. • To have easy-to-use maps/ atlas with important amenities, services, open spaces, shortest routes, helipad, hospital, police stations. • To ensure uniform response action plan for cross-departmental coordination and better clarity of roles and responsibility. • To establish control rooms in safe locations for managing emergency situations and providing communication to the state and national teams, if needed. • To establish an emergency cell with assigned nodal persons in all departments composed of trained response and rescue staff.
Owner	Cuttack Municipal Corporation
Supporter	Odisha State Disaster Management Authority District Collector of Cuttack
Current Scenario	Currently, all the departments are dependent on the DC office for instruction in an emergency situation. There is no interdepartmental coordination and action plan for response and rescue.
Benefits	• Better preparedness leads to lesser response time. • Pre-planned rescue operation will lead to less calamities and financial loss, and will also help the town get back to its normal state faster.

Action: 8	Inter-departmental Ordinance for Standard Operating Procedure (SOP)
Sector	Comprehensive Institutional Set-up
Objective	To have a resolution for highlighting the required legislative framework which can aid in the operational process by creating a platform for aligning all key departments at the district level.
Timeline	2017-2018
Brief	• The interdepartmental ordinance will increase the coordination between the various departments, which will provide clarity for the departmental scope of work. • In emergency situations, it is very important to have defined roles and responsibilities. • The meet can be intended to assign roles and responsibilities of all agencies and develop Standard Operating Procedures (SOPs) and interoperability mechanism. • The resolution will also provide further clarity on community reach and coordinated engagement for different government plans and programmes. • The ordinance can be managed by the DC office within each district headquarters. • The meet should have a representative from the state administration, so that the upcoming state-level plans and programmes can be discussed from the disaster management perspective comprehensively.
Owner	Cuttack Municipal Corporation
Supporter	Odisha State Disaster Management Authority District Collector of Cuttack
Current Scenario	All the line departments have very limited interaction regarding disaster risk management. One good practice for the same is pre-monsoon activity meet in all the district headquarters.
Benefits	• Clarity of roles and responsibility across departments with respect to disaster management • Faster response in emergency situations with clear understanding of available resources • Wider reach by including awareness in the existing programme

Action: 9	Community Level Risk Awareness Programme
Sector	Community Awareness and Participation
Objective	To build response capability by integrating and empowering/ training the local communities and citizens.
Timeline	2017-2018 and Periodic Update
Brief	• To make communities aware of disaster risks and vulnerability. • Basic training for risk mitigation at the household level. The awareness programme should have first aid measures and other adaptation measures, such as insurances, financial security, health etc. • To make community aware of the structural measures which are mandatory for their buildings. • To make different departments aware of their roles during emergency situations. • To have a disaster management section in the secondary level education curriculum.
Owner	Cuttack Municipal Corporation
Supporter	Odisha State Disaster Management Authority District Collector of Cuttack
Current Scenario	People are not aware of the structural measures at community level/ household level. Building licencing is also not monitored well. Awareness on the importance of insuring properties is limited.
Benefits	• Awareness on vulnerability from risks, available services and processes to seek help from the respective administrative departments • Awareness of basic precautionary measures in events of disaster • Basic understanding of mitigation techniques and risk management for building long-term resilience.

Action: 10	Establishing an Integrated and Real-time Vector/Water-borne Disease Surveillance and Response System
Sector	Preparedness for Disaster Risk Reduction
Objective	To establish an Integrated and Real-time Vector/Water-borne Disease Surveillance and Response System for Cuttack.
Timeline	2017-2018 and Periodic Update
Brief	• The overall objective will be to demonstrate and establish an integrated and real-time disease surveillance, monitoring and tracking system for vector/water-borne diseases to facilitate city nodal agencies and stakeholders to take timely preventive and precautionary interventions to check their spread and to reduce the vulnerability of poor communities to these diseases.
Owner	Cuttack Municipal Corporation
Supporter	Odisha State Disaster Management Authority District Collector of Cuttack Chief District Medical Officer of Cuttack
Current Scenario	• Inadequate sanitation scheme across the city. This results in prolonged water logging in some parts of the cities. • The incidence/coverage of urban flooding was noticed and documented during review. • The city doesn't have a near-real time health surveillance system. The existing system is weak and doesn't involve a wide range of stakeholders. Due to deficient prevention measures, there are frequent outbreaks. Absence of active surveillance system has resulted in tackle outbreaks of water borne diseases.
Benefits	This system will help that can facilitate near-real time active disease surveillance. The current system relies upon volunteers to collect disease information from various location in cities. Being paper based, this system is prone to errors of omission and commission in collection and entry. This system is largely unorganized with very little monitoring leading to delayed response to spread of diseases especially during monsoons. In order to overcome the above problems, the proposed system will stream line the disease surveillance process and ensure timely dissemination of information to public health authorities. Geographically explicit information will be provided on a daily basis to the public health department for taking timely action, prevent outbreaks resulting in epidemics. The response (action to be taken) towards any disease outbreak will be according to the existing health departments protocols and the proposed system will facilitate that process. The system will be housed within the health department, and will be integrated with their current information collection mechanism.

SUMMARY

It is important at this stage to note that EWS in the Cuttack city needs to be upgraded significantly to meet the larger objective of reducing fatalities and protecting infrastructure/assets from future events. It is recognized globally that an operational EWS has the potential of minimizing loss and contributing to sustainable development and building resilience. While technology is available for establishing the robust communication system for EWS, it is the institutional foundation and the networking arrangements which have to be deep rooted for meeting the desired objectives of the system. All the key elements of the system have to be functional and it is important to review them annually by targeting for different scenarios and measuring performance.

This report provides insights to issues that need to be addressed for an operational EWS, defines the criteria and measures the development stage indicators for the present situation. The results of this review provide a status and the need to be aware of key design considerations for improvement of existing EWS, as well as for design and implementation of new EWS. It is envisaged that city landscape will have to tailor solutions for public safety, and EWS will be designed and developed on various platforms. It is important to keep these systems people-centric and subsequently build risk knowledge among the stakeholders for success of this system. Criteria Development Matrix can be used as a tool for further review. As EWS systems develop in the city, robust EWS audit mechanism can be rolled in the future to measure system efficiency.

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