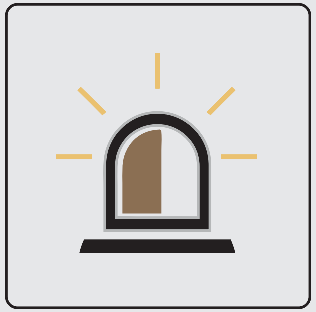
Review Of Early Warning System in Bhubaneshwar, Gangtok, Madurai, Navi Mumbai, Shimla, Thiruvananthapuram And Visakhapatnam



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ACKNOWLEDGEMENTS

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The review process involved a number of consultation meetings and workshops in the cities. The support of the city government and State Government departments/ institutions is highly appreciated.

Specifically we would like to highlight the support and in-depth engagement of the City Project Coordinators from all the seven cities.

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.

TARU

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Edited by: Anup Karanth and Umamaheshwaran Rajasekar
Authors: Anup Karanth, Dr. Sandhya Rao, Dr. Umamaheshwaran Rajasekar, Lalit Dashora
Team Composition: Prof. A.K. Gosain (Team leader), Dr. Umamaheshwaran Rajasekar (Deputy Team leader & System Analyst), Anup Karanth (Disaster Risk Management Expert & Project Manager), Dr. Sandhya Rao (Institutional & Capacity Assessment Expert), Puja Singh (Hydro-meterological hazard Risk Assessment Expert), Lalit Dashora (Urban Risk Assessment and Decision Support Expert)
Graphics and Design by: Vishal Mehta and Mansi Shah

EXECUTIVE SUMMARY

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.

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.

Adoption of the Hyogo Framework for Action (HFA) during the World Conference on Disaster Risk Reduction (2005, Japan) has 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. The second high priority area of the HFA stresses the need for identifying, assessing and monitoring disaster risks and enhancing early warning.

This review is commissioned by UNDP under Contract (2013/067), and is an initiative under the programme titled, "GoI-UNDP Climate Risk Management in Urban Areas through Disaster Preparedness and Mitigation Project". 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 seven cities (Bhubaneswar, Gangtok, Madurai, Navi Mumbai, Shimla, Trivandrum and Vishakapatnam). 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 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 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 cities:

- EWS development is crucial for sustainable development and building resilience of the cities. 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. A long-term perspective on capacity development should be envisaged.
- There is a common challenge in the interpretation of the forecast products. 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
ADM	Additional District Magistrate
BMC	Bhubaneswar Municipal Corporation
BSNL	Bhartiya Sanchar Nigam Limited
BUDA	Bhubaneswar Urban Development Authority
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
CMO	Chief Municipal Officer
CWC	Central Water Commission
DCP	Deputy Commissioner of Police
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
HFA	Hyogo Framework for Action
IC	Incident Commander
IDSP	Integrated Disease Surveillance Programme
IMD	India Meteorological Department
INCOIS	Indian National Center for Ocean Information Services
IRS	Incident Response System
IT	Information Technology
M&E	Monitoring and Evaluation
MHA	Ministry of Home Affairs
MHRVA	Multi Hazard Risk and Vulnerability Assessment
MSK	Medvedev-Sponheuer–Karnik Intensity Scale
NDMA	National Disaster Management Authority
NGO	Non-Governmental Organization
OSDMA	Odisha State Disaster Management Authority
PAS	Public Addressal System
PHD	Public Health 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
SDMA	State Disaster Management Authority
SEOC	State Emergency Operations System
SMS	Short Messaging Service
SOP	Standard Operating Procedures
SRC	State Resource Center
ULB	Urban Local Body
UNDP	United Nations Development Programme
WRD	Water Resource Department

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

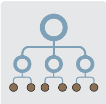
Risk management
The systematic approach and practice of managing uncertainty to minimize potential harm and loss

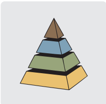
Vulnerability
The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard

Source: 2009, UNISDR Terminology on Disaster Risk Reduction

LIST OF ICONS


Background informartion on Review of EWS in 7 cities in India under the ongoing intitatve of Climate Risk Management in Urban Areas through Disaster Preparedness and Mitigation project by UNDP.

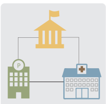

Methodology/Systematic approach adopted to assess the existing EWS and emergency communication netwrok in 7 cities across India.


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.

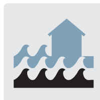

Summary of all the criteria of all 6 components of study framework and discussed in brief.

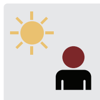

Earthquake

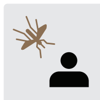

Tsunami


Landslide


Cyclone


Flood

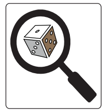

Heatwave

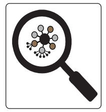

Public health risk


Observation and Monitoring


Data Analysis

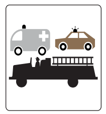

Prediction


Risk Assessment


Potential Impact Assessment


Warning Formulation


Dissemination to communities at risk


Preparation of Response


Community Response

1. INTRODUCTION

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.

Adoption of the Hyogo Framework for Action (HFA) during the World Conference on Disaster Risk Reduction (2005, Japan) has 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. The second high priority area of the HFA stresses the need for identifying, assessing and monitoring disaster risks and enhancing early warning.

In recent years hazards of different origin have caused significant loss of lives and economic damages. 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 a national 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.

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 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. 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 seven 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 seven 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 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 seven 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.

Case studies of best practices and warning system for individual hazards are presented at the end of the city review sections for ready reference.

Figure 1**: Seven cities selected for review of EWS**

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 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 (say, for 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

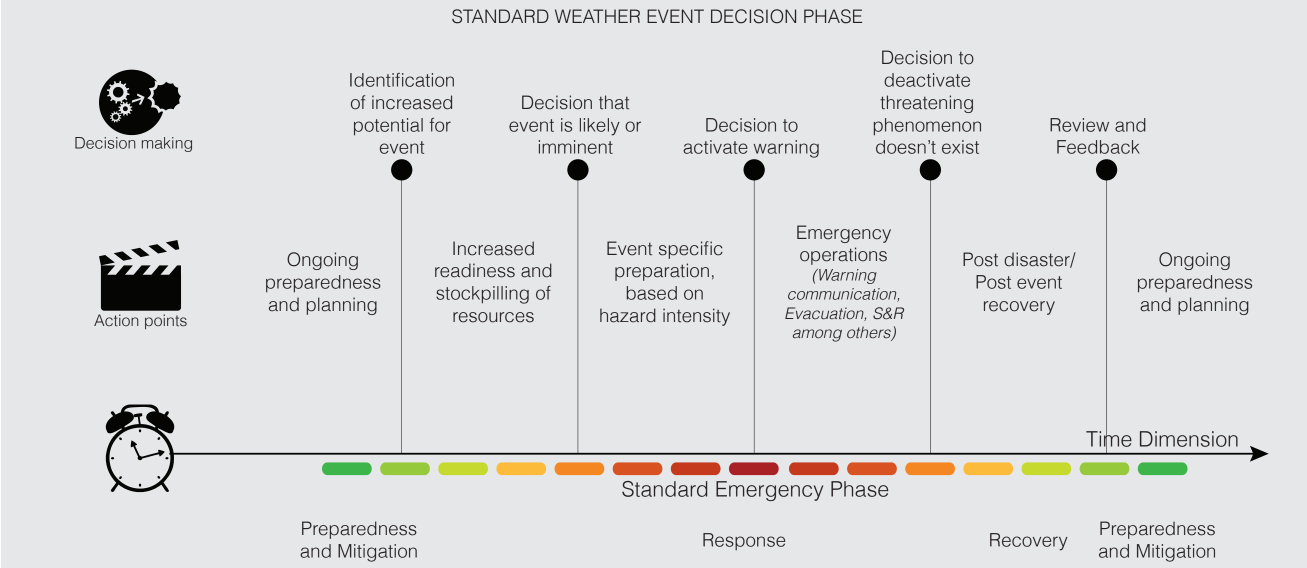


Figure 2: **Highlighting overlay of decision points over standard emergency phase and the weather event decision phase**

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
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

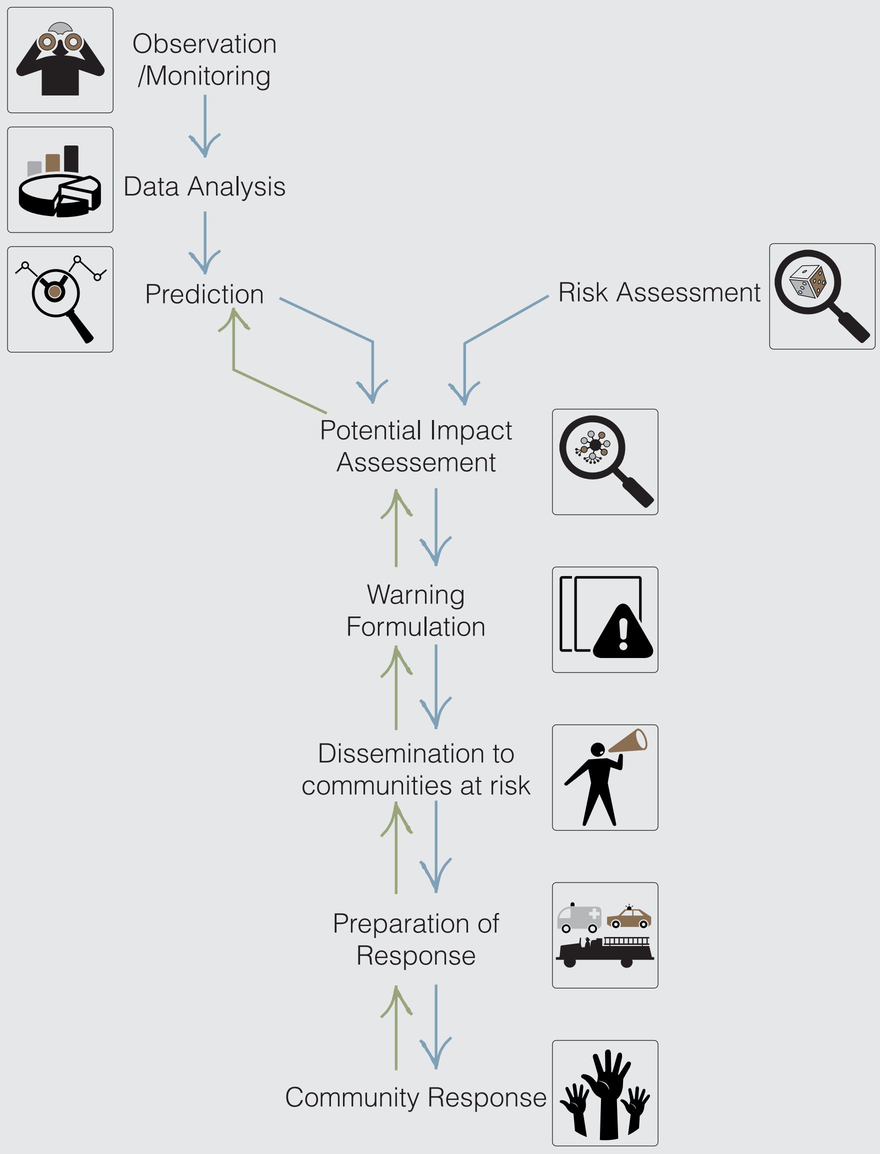


Figure 3: **Key elements in end-to-end EWS**

2. METHODOLOGY OF 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 seven 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, municipal corporation 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).

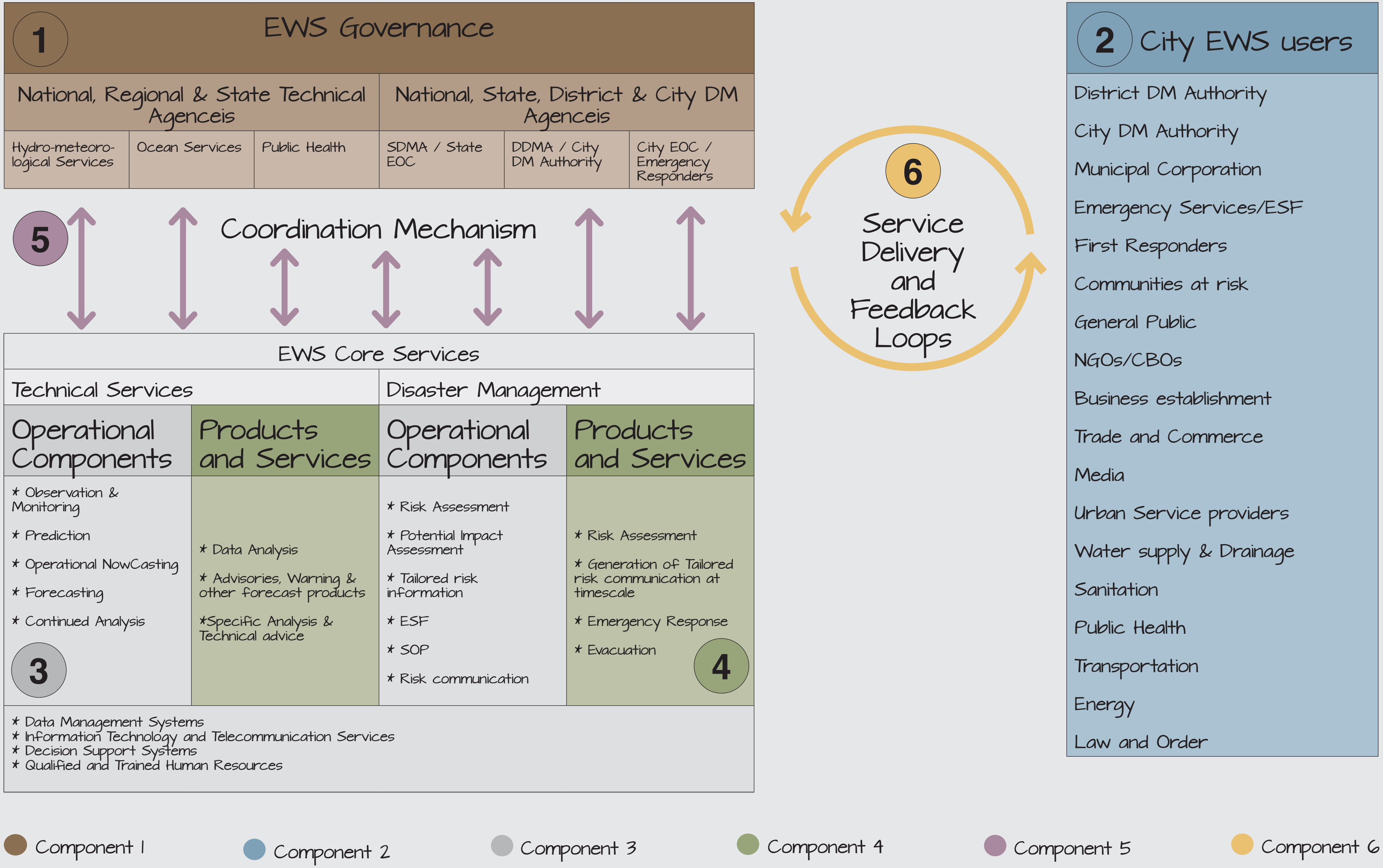


Figure 4**: Study framework schematic showing the links of stakeholders across the development model of EWS**

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 seven 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

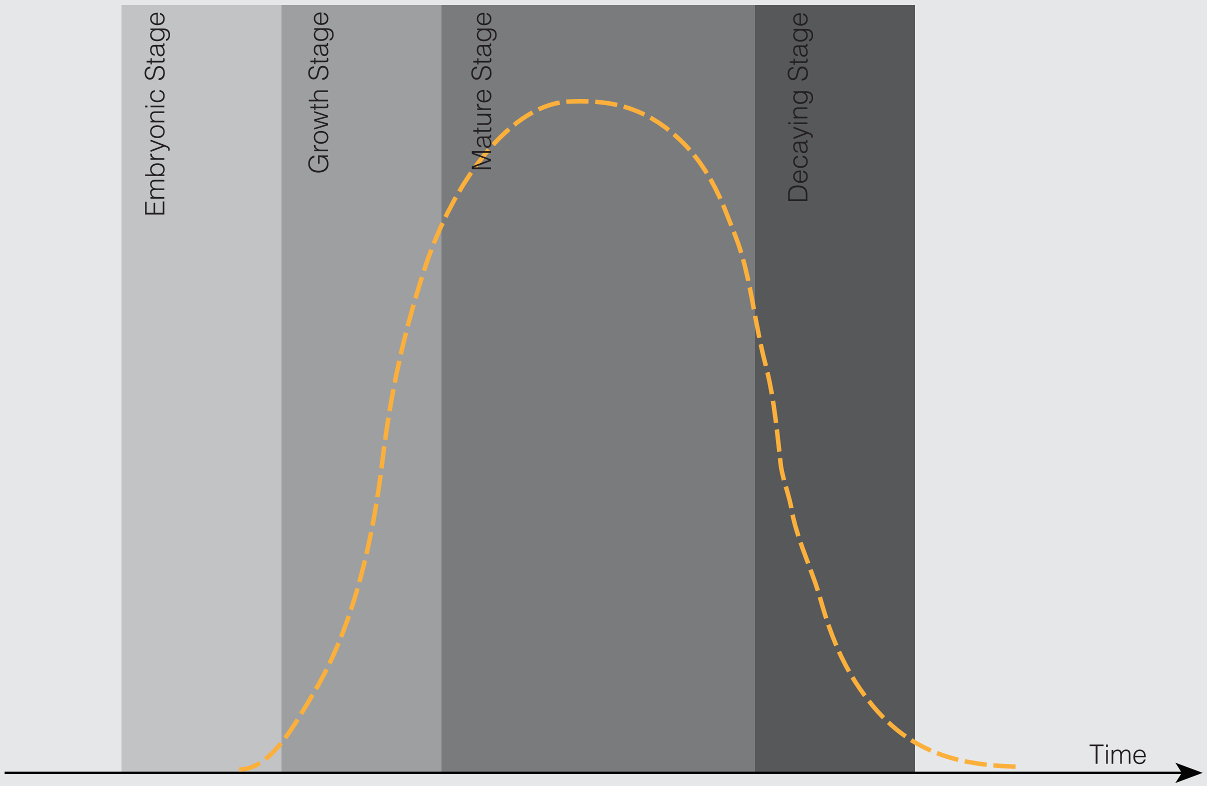


Figure 5: **Evolution of an hazard event in four stages**

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.

begin to take shape, such tropical cyclone. In the 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.

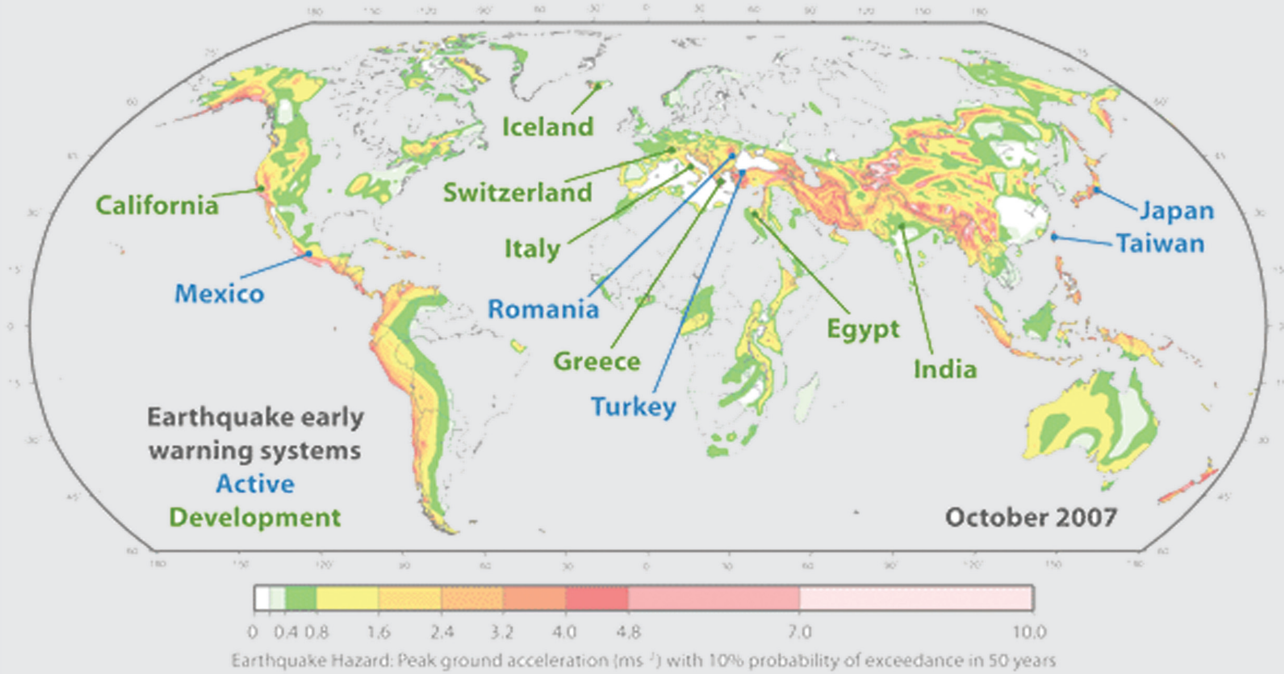


Figure 6: **Global earthquake hazard map showing the regions operating active earthquake early warning systems**

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

Given the high vulnerability of the country to 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**

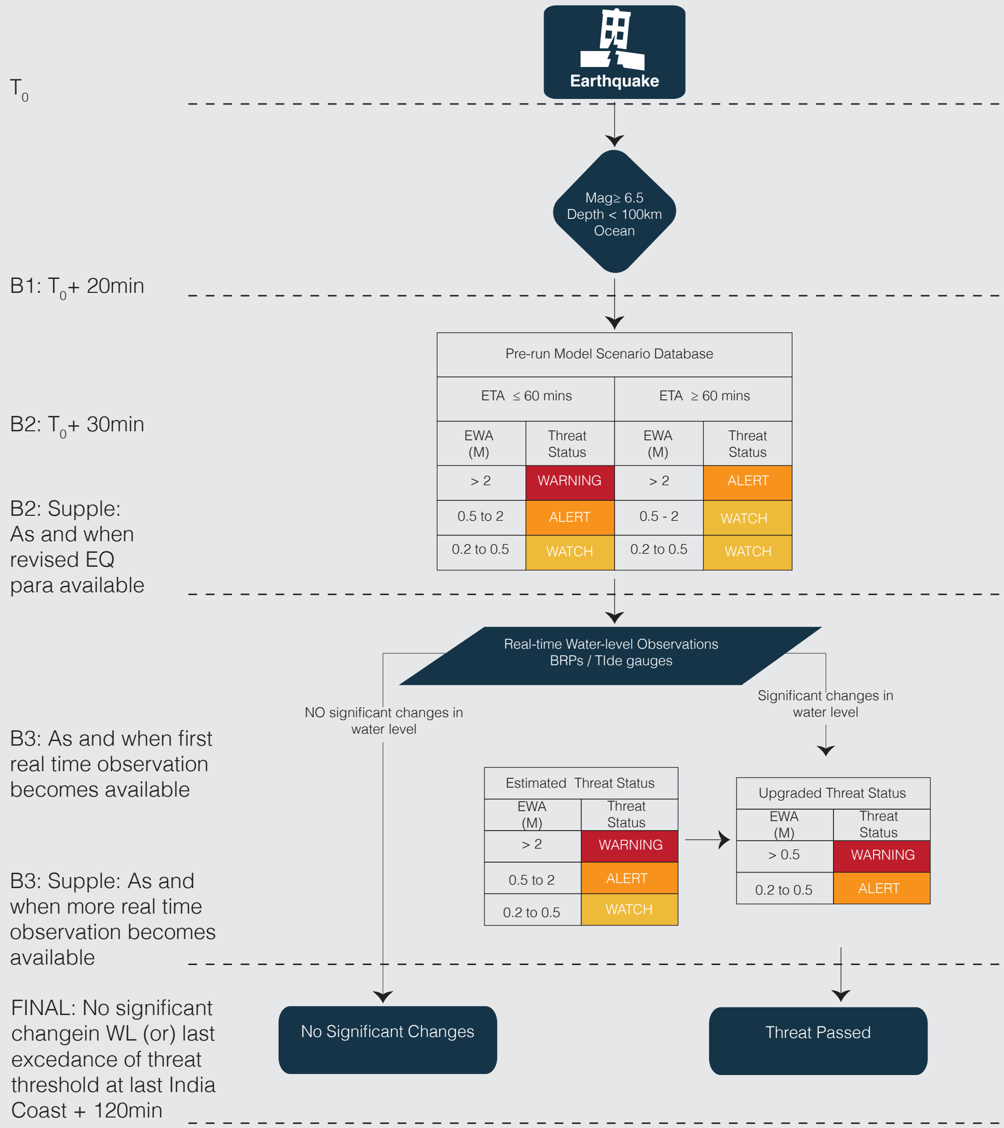


Figure 7**: SOP diagram of tsunami early warning centre**

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
- 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

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**

• 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 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

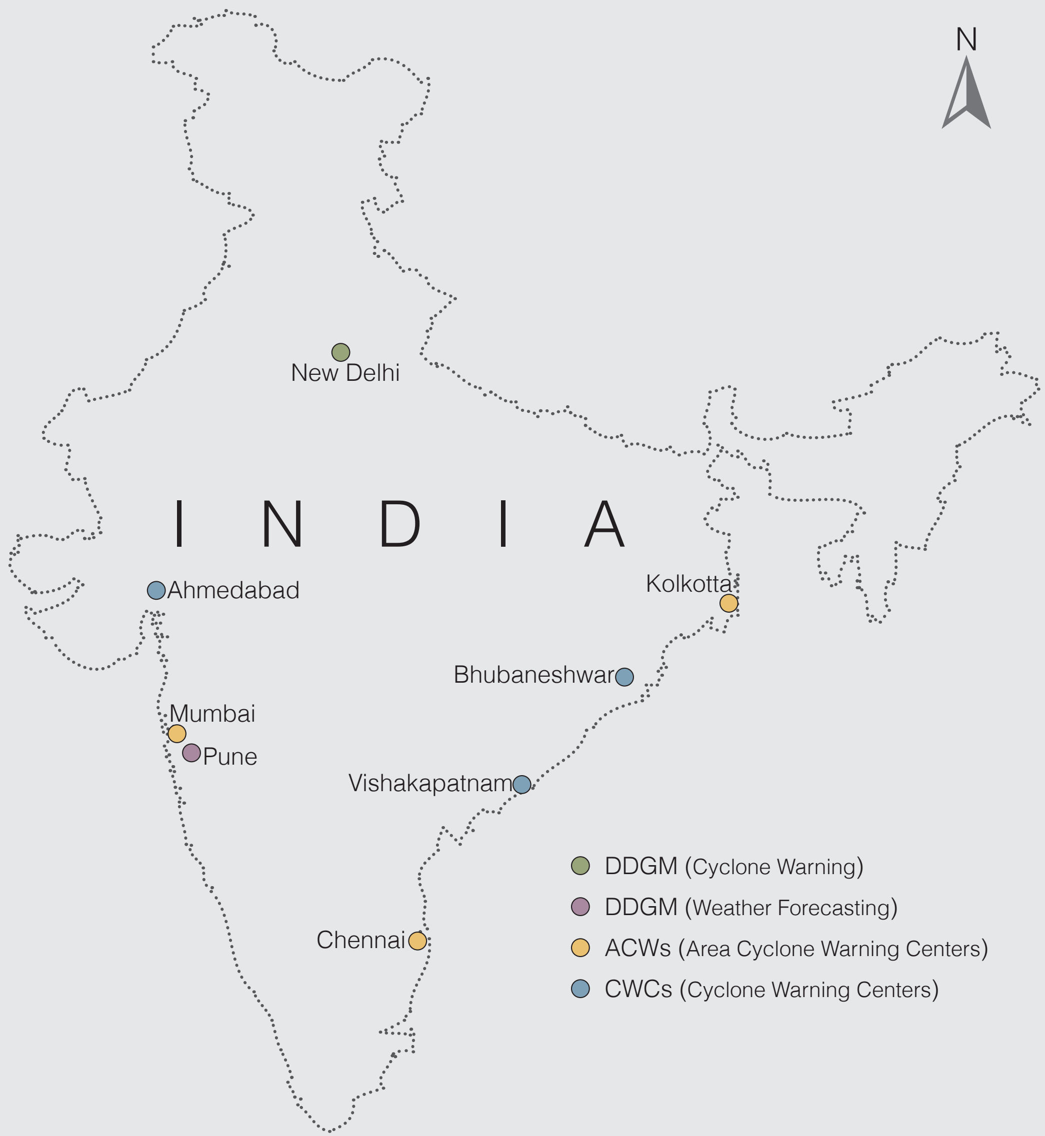


Figure 8**: Cyclone warning organization structure**
Source: http://www.imd.gov.in/section/nhac/dynamic/cwo.pdf

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 and 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:

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

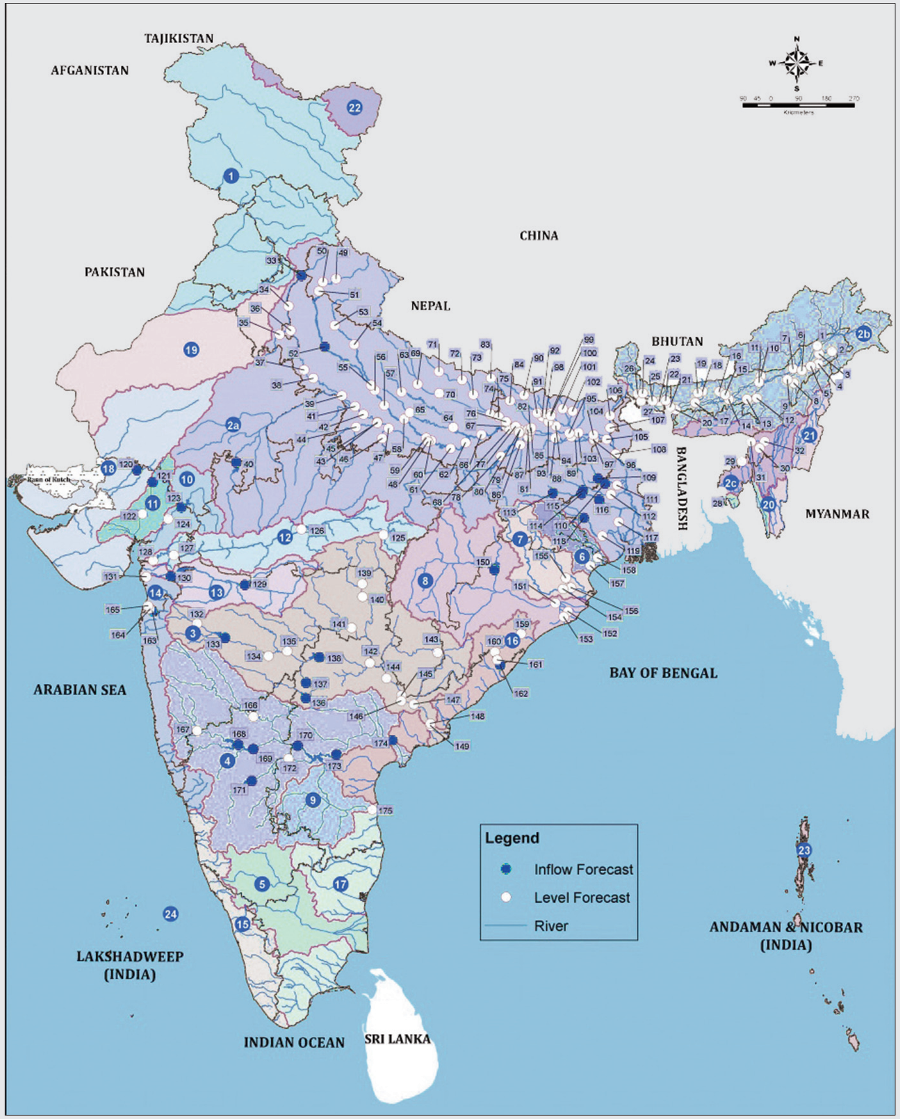


Figure 9: **Flood forecasting stations in India**
Source: http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=CWC_National_Flood_ Forecasting_Network. Last accessed on 19 April 2014

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 prolonged 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.

BHUBANESWAR

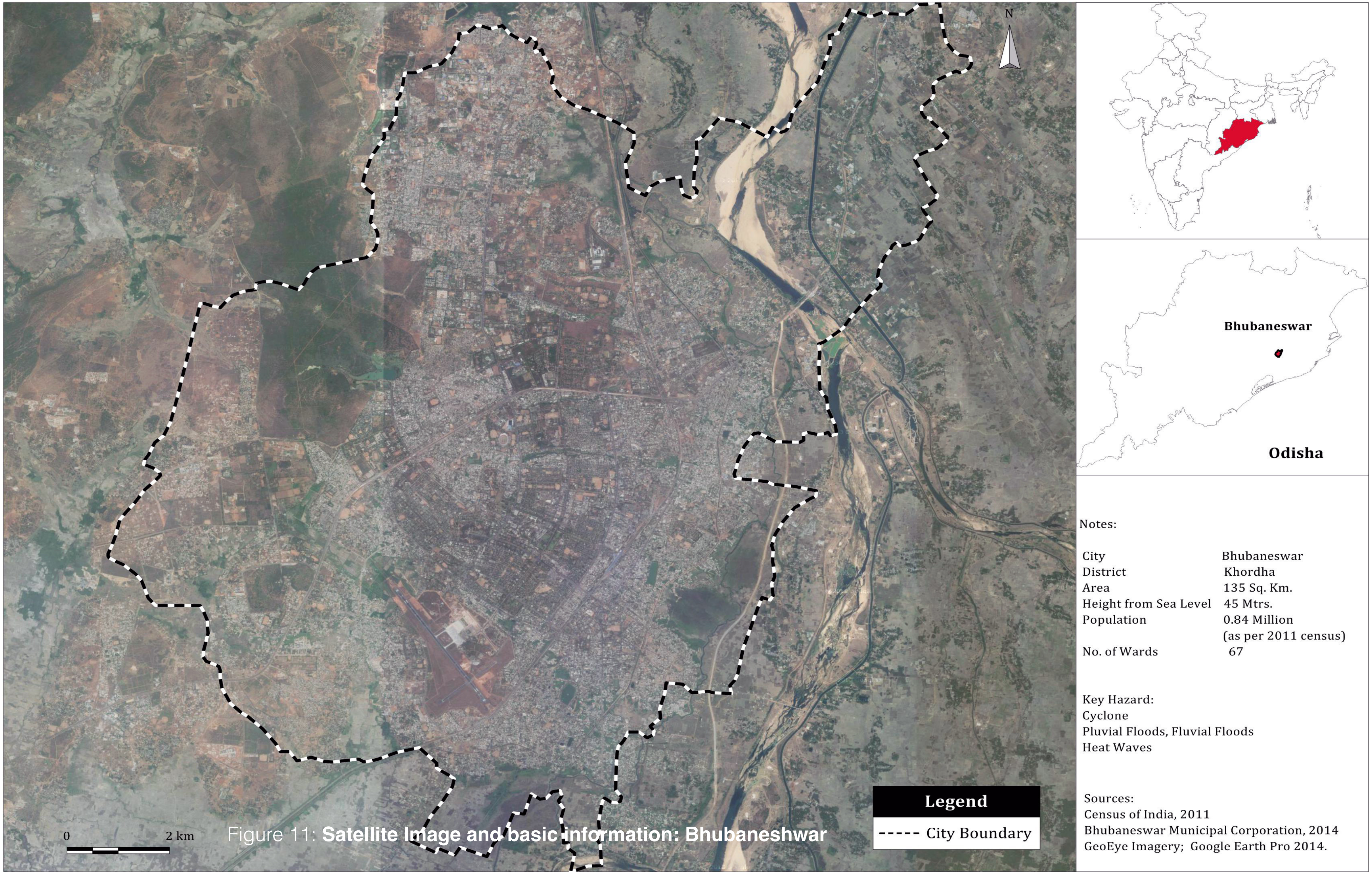


Figure 11: **Satellite Image and basic information: Bhubaneshwar**

5. REVIEW OF EWS IN BHUBANESWAR

5.1 GENERAL CITY INFORMATION

Bhubaneswar is the capital of the state of Odisa located in the district of Khurdha. The city is situated in eastern coastal plains (approximate aerial distance of 55km from the coast of Bay of Bengal) at an elevation of 45m above sea level. Mahanadi River flows along North-eastern part of the city, with its distributaries Daya and Kuakhai. The city is known for its temples and therefore caters to number of tourists from within and outside the state.

The future and the zoning regulations of the city's periphery is managed by the Bhubaneswar urban development authority (BUDA) and the city administration for services such as Solid Waste Management, Underground Sewerage System, Slum Development, Disaster Management, Health & Sanitation are managed by Bhubaneswar Municipal Corporation (BMC). BMC was formed in 1994 and it currently caters to population of 837,737 people spread across an area of 135 sq.km. The city is divided into 60 wards[1] and 40 revenue villages.

5.2 BACKGROUND ON HAZARD RISK

Geophysical Hazard

Earthquake: The state of Odisha falls in low and moderate seismic hazard. The city of Bhubaneswar and its surrounding fall within zone III (due to high dense concentration of sub-surface faults around that region). Zone III indicates moderate risk zone (intensity up to VII on MSK scale). Instrumental historical records indicate no earthquake events of magnitude greater than five occurring in the past; there have been incidences of earthquake events of magnitude four or lower having occurred in this region.

Hydro-Meteorological Hazard

Bhubaneswar is characterized by tropical savannah climate (equatorial desert climate under the Köppen climate classification[2]). The annual mean temperature is 27.4 °C, while the summers and monsoons (March to October) are hot and humid with average temperature ranging from 25 °C at night to 36 °C during the day. During winter (November to February), average temperature ranges between 16 °C to 28 °C. The city experiences a total annual rainfall of around 1470 mm. While the monsoon period is from June to October, the months of July and August cater to over 40 per cent of the total annual rainfall.

With 80 per cent of annual rainfall concentrated over three months, the city is highly vulnerable to water logging and floods. There is probability of flooding because of the Kuakhai and the Daya. High population density, encroachment on natural drainage systems, poor socio–economic condition and weak infrastructure increase the vulnerability.

The important distributaries and sub-distributaries of the river Mahanadi traversing the district of Khordha and the city of Bhubaneshwar are Kuakhai and Daya having southerly and south-easterly flow. The district of Khordha is also frequently affected by fluvial floods (seven floods between the 15-year period: 1995 to 2010) while the city of Bhubaneswar is generally affected by pluvial floods (almost every year) with an exception of extreme events – especially the super cyclone of 1999 and the major floods of 2008[3] .

Due to the city's proximity to the coast, the relative humidity experience is high. This, combined with incidences of high temperature (days where the temperature is greater than 40 °C), leads to heat wave-like conditions. The interviews indicate that over the past decade, the incidences of heat wave are on the rise. Based on the experience of heat wave disaster (1999), the city residents are well aware of the situation. Warnings for heat waves are provided by IMD through the local media to help raise awareness and to prepare city residents for the situation. Even though there has been a rise in the number of extreme hot days, the number of causalities associated with the same is on decline. This can be attributed to the existing system of early warning with action points provided to the residents in time. There has also been a noticeable change in attitude/behaviour of people by attempts being made to avoid working outdoor/travelling during the days when warnings are issued.

[1] *http://bmc.gov.in/BMCProfile.asp?lnk=1&PL=4 accessed on 10 September 2013.*
[2] *http://koeppen-geiger.vu-wien.ac.at/pdf/kottek_et_al_2006_A4.pdf accessed on 10 September 2013.*
[3] *City disaster management plan 2011–12*

Public Health Risks

Water-borne and vector-bone diseases are some of the key concerns of the city administration. The recent expansion of the city with limited coverage of water supply and sewerage networks, especially along the peri-urban areas, acts as breeding ground for diseases. The recent incidence of H1N1, dengue and malaria are some examples of outbreak, which are being addressed by the city administration. While general recommendations are being provided by the media, the health department, BMC and IDSP have realized the need to monitor and provide timely warning at the early onset of an epidemic.

5.3 BRIEF VULNERABILITY PROFILE

The city and its infrastructure are vulnerable to incidences of both geophysical and hydro-meteorological events. The interviews and subsequent field visits by the monitoring team identified the vulnerability of the existing drains and the associated infrastructure. 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 vulnerability 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.

Bhubaneswar is an industrial city and this has led to the migration of people within the state in search of jobs. According to the slum profile prepared by Bhubaneswar Municipal Corporation in 2008 there exists around 377 slums with the city limits. Within these around 99 slums are authorized and remaining 278 slums are unauthorized (illegal settlements). In addition, several tourists and residents do conglomerate to witness temple architecture and religious functions organized by the temples respectively. Due to migration, catering to the growth of unauthorized slums, and rapid expansion, leading to the emergence of infrastructure, especially along the flood plains (due to limited enforcement of land regulations), events of extreme rainfall will have an impact on these social strata. In addition, any extreme event may have a larger impact if it coincides with a religious event where the conglomeration of people at select locations is bound to be large.

In addition to being a state capital, Bhubaneswar is an important centre for trade and commerce. The commercial activities of the city have grown to cater to the needs of the entire region. The major organized commercial areas are in 13 locations accommodating more than 10,300 commercial establishments. Unorganized commercial areas and weekly haats are identified in 34 locations, accommodating 3300 commercial establishments employing an estimated 7000 people and mainly having shops made of planks or kiosks. An event such as cyclone or earthquake is likely to have tremendous socio–economic impact.

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.

Indian Meteorological Department

The 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 centre in Pune to process the data and provide both regional and local weather information.

IMD currently provides nowcast 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

May, 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 centre 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.

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 centre, IDSP.

Odisha State Disaster Management Authority, State Emergency Operation Centre And District Disaster Management Cell
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) 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 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.

Bhubaneswar Municipal Corporation

Municipal Commissioner, BMC, will activate the EOC to assess the situation during disaster. BMC will ensure proper functioning of the control room, monitoring information flow within the control room, coordination with the ward through junior engineers and elected representatives. The city EOC will coordinate with Additional District Magistrate (ADM), office of SRC, OSDMA, Office of District Magistrate (DM) Khordha, Office of Deputy Commissioner of police (DCP) Bhubaneswar, BSNL, Sub collector, Tahsildar, Fire officer, Central Electricity Supply Utility of Odisha (CESU), Public Health Department (PHD), sub-divisional veterinary officer, Indian Red Cross Society and Capital Hospital.

The Commissioner, BMC, is the Incident Commander (IC) to activate the command system and to control and coordinate the resources required at the site of disaster. The Incident Response System (IRS) is a set of emergency management tools consisting of the combination of facilities, equipment, personnel, procedures and communications operating within a common organizational structure, with responsibility for the management of resources to effectively accomplish stated objectives pertinent to an incident. In the Bhubaneswar city, the function of IC is commanded by the Commissioner (Bhubaneswar Municipal Corporation) for planning, directing, organizing, coordinating, communicating and delegating roles and responsibilities to the City Emergency Managers.

Municipal Commissioner, BMC, with support from Director, Indian Meteorological Department, Bhubaneswar, All India Radio, Doordarshan, office of DCP, tahsil office, CDPO (Urban), Bhubaneswar, Capital Hospital, BMC Hospital will collect, process and disseminate information about an actual or potential disaster situation to facilitate the overall activities of all responders in providing assistance to an affected area. BMC will also establish contact with the state authorities to coordinate planning procedures between the city, district and the state.

Chief Engineer (PHD), Bhubaneswar, with support from engineers (BMC and BDA) will ensure the provision of clean drinking water and special care for women with infants and pregnant women. They also ensure that sewer pipes and drainages are separated from drinking water facilities.

City Health Officer, Bhubaneswar Municipal Corporation, with support from other engineers (BMC), Bhubaneswar Development Authority (BDA), roads and bridges department, sub-divisional veterinary officer, divisional forest officer, rapid action force, people for animals and NGOs will ensure the desilting of drains, clearing routes and restoration of sanitation facilities. They will also monitor and ensure that food and water are not contaminated during and post-disaster.

Health

Chief Medical Officer (CMO), Capital Hospital, Bhubaneswar, is responsible for public health. The CMO, with support from chief district medical officer (CDMO) Khordha, BMC Hospital, CMO, Railways Hospital, Indian Red Cross Society and St. Johns Ambulance, will coordinate, direct and integrate city level response including activation of medical personnel, supplies and equipment, contain outbreak of epidemics and coordinate with BMC in their activities.

Police

During an event, Deputy Commissioner of Police (DCP) will be responsible for coordinating communication with BMC, OSDMA, Fire Officer, BSNL, All India Radio, Indian Meteorological Department, Central Water Commission, Doordarshan and Civil Defense.

Media

Media play an active and significant role in the early warning communication within the city of Bhubaneswar. Local media (print) collect information from IMD and WRD and disseminate it to the public at large through their publications. In case of extreme events, they also collect information from the disaster management agencies to provide warning along with action points to the public. This is done more frequently for heat waves and disease outbreaks.

5.5 INDICATORS OF THE EXISTING CONDITION OF EWS

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

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)	●	●	●	○	○	The City DM Plan mentions ULB taking charge of preparedness and response. Mention of EWS is not evident
1.2	Institutional mechanism for local authority (ULB) is an integral part of EWS framework (document, mandate, implementation)	●	○	○	○	○	The City DM Plan has no mention of warning system for geophysical, hydro-met or public health hazards
1.3	ULB accorded with the authority to disseminate warnings (mandate, SOP, implementation)	●	●	●	○	○	The municipal commissioner is accorded with the responsibility of being the Incident Commander in case of an event (CDMP). While, dissemination of public health advisories for disease outbreaks were evident, the warning for hydro-met is provided by technical institutions
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 actions were evident for hydro-met and public health risks

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; this was evident for extreme rainfall and diseases
2.2	Outreach practice (dissemination of warning)	●	●	●	○	○	Forecast exists for weather events, warning exists for all key hazards (excluding earthquake and landslide), information is provided by IMD and health department to government institutions and media
2.3	Timely dissemination of warnings to vulnerable groups (residing in slums, high risk prone areas)	●	●	●	●	○	Warning of disease outbreak is provided to slums through IDSP
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	●	●	●	○	○	Media collect information from IMD, 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 as it is with no value additions
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)	●	●	●	○	○	Health Department, Municipal Corporation, currently provides only health advisories

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)	●	●	●	○	○	City level risk assessment has been undertaken, qualitative ward level hazard indication has been mapped. The information developed is rudimentary and therefore currently not being used for potential impact assessment
3.2.1	Warning mechanism for geophysical hazards (earthquake)	●	○	○	○	○	Realization of need for warning is evident across institutions
3.2.2	Warning mechanism for hydro-meteorological hazards (cyclone, severe winds, heat wave, cold wave, extreme rainfall, fluvial flooding, pluvial flooding)	●	●	●	●	○	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. Non-availability of information regarding the local impact reduces the respite time.
3.2.3	Advisory mechanism for public health risks (vector-borne and water-borne diseases)	●	●	●	●	○	Warning provided by 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
3.3.2	Availability of technology in nowcast/forecast of hydro-meteorological hazards by technical agencies	●	●	○	○	○	Technology to forecast and nowcast being implemented by IMD
3.3.3	Disease surveillance system (surveillance coverage, collection method, analysis)	●	●	●	○	○	Monitoring of health information at district level is being carried out by IDSP 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 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	●	○	○	○	○	OSDMA has made attempts to collate data, ULB is currently not involved in the process of collection or collation.
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 city will not be directly affected by landslide or tsunami. There is no warning mechanism established for earthquake to be disseminated. There are two sirens, which are currently operational, to disseminate hydro-met warning. One is located at EOC and the other at IMD. There is plan for installation of digital displays. 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 state EOC is located within the city, and is realized to function for the state 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

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 for hydro-met and public health.
4.2	Raising awareness 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 there is realization for need of specific products by various departments, especially for the hydro-met and public health risks
4.4	Risk communication	●	●	●	○	○	Risk assessment is not comprehensive at the city level. The information generated by the technical agency 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 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.
5.2	Extent of links between disaster management agencies and service providers	●	●	●	●	●	Formal linkages between agencies is evident through mail, fax and phone communications.
5.3	Extent of links between media and disaster management agencies	●	●	●	○	○	Reflection of warning information in media products are evident (daily). Linkages between media and technical agencies were found to be more strong through their frequency of interaction in comparison to the disaster management agency

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 and service providers are aware of the warning but little evidence (only IDSP vs Health Department) of coordinated actions was evident.
6.2	Extent to which the warning mechanism allows for feedback from the affected area	●	●	●	●	○	Two way communication systems, such as ham radio, are in place for cyclone and fluvial floods. They are not being used for pluvial floods by ULB or disaster management agency to coordinate actions. In case of public health, it is achieved through field workers providing feedback on a weekly basis
6.3	Level of reflection and learning evident within local authority	●	●	○	○	○	Post-event reflections are evident in the case of heat waves (post-1999 incident) and cyclone (super cyclone, 1999). There is also evidence of increased communication and response mechanism (setting up of state institutions, decrease in the number of deaths due to heat strokes)
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

Bhubaneswar, being the capital city of Odisha, has the advantage of being the headquarters for all key State Government and regional institutions. The presence of Odisha State Disaster Management Authority (OSDMA), the State Emergency Operation Centre (SEOC), Department of Water Resources (DoWR), emergency management cell, Indian Meteorological Department's (IMD) regional centre for cyclone warning and State Surveillance Unit (SSU) of Integrated Disease Surveillance System (IDSP) has led to spurious perception within urban local bodies to not have an early warning system for the city.

The city municipality released its first city disaster management plan in 2012. This comprehensive document has indication of local authority being the nodal agency for incident command, 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 and warnings 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 city disaster management cell and city EOC, the 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.

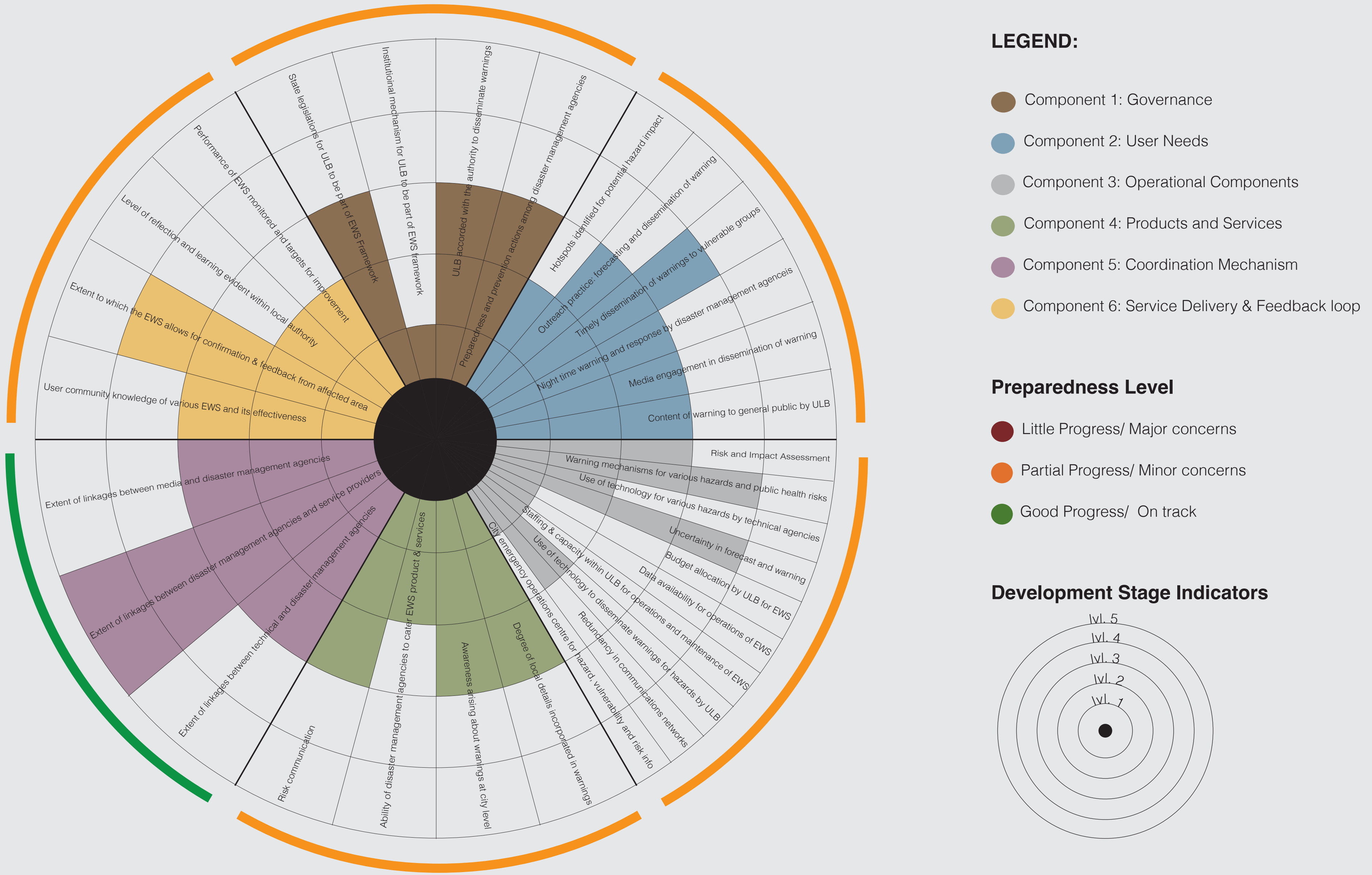


Figure 12**: Preparedness of EWS indicators for Bhubaneshwar**

GANGTOK

Figure 13: **Satellite Image and basic information: Gangtok**

Notes:

City	Gangtok
District	West Sikkim
Area	35 Sq. Km.
Height from Sea Level	1600 Mtrs.
Population	0.10 Million (as per 2011 census)
No. of Wards	15

Key Hazard:
Earthquake, Landslide
Floods, Flash Flood, Lightning, Hailstorm,
Cloud Burst, Cold Waves

Sources:
Census of India, 2011
Gangtok Municipal Corporation, 2014
GeoEye Imagery; Google Earth Pro 2014,

6. REVIEW OF EWS IN GANGTOK

6.1 GENERAL CITY INFORMATION

Sikkim is a mountainous state consisting of steep slopes and complex geology. The entire state is located in seismic zone IV. The number of important tectonic features including Main Boundary Thrust (MBT) and Main Central Thrust (MCT) are in close proximity. Elevation of the state varies between 244 m at south to 8534 m in north (Bhasin et al., 2002). The altitude of the state plays a major role in controlling the climate. It experiences warm summers and cold winters. Northern part of Sikkim, due to its high altitudes and mountains, gets high snowfall in winters. The region receives an average annual rainfall of around 3494 mm in about 164 days of the year (UDHD, 2011).

Gangtok, the state capital of Sikkim, is also the district headquarters of East district and is one of the main tourist destinations. The area of Gangtok is around 19.62 sq km and is located on the steep slopes of Sikkim Himalaya with an average altitude of 1667 m above the mean seal level.

Gangtok city is located on top of a ridge (flat) oriented in NE–SW direction and sloping down in NW–SE direction. The city has grown in a linear fashion along the ridge line. Recently, the city has also started growing towards the NW direction as the slope on the western side of the hill has a gentle slope than the other side. Because of this kind of skewed development on one side of the hill slope, the city's building and settlement pattern and other infrastructure like water supply and sewerage systems are also located on one side of the hill slope, thus affecting the slope stability of the region.

6.2 BACKGROUND ON HAZARD RISK

Geophysical Hazard
The Sikkim Himalaya, which is a part of northeast India, is seismically one of the six most active regions of the world. Sikkim has a very long history of earthquakes. Moderate earthquake (reported as Mw 5.3 by USGS and as ML 5.7 by IMD) occurred in the state of Sikkim (India) on 14 February 2006 at 06:25:23 a.m. local time. The earthquake's epicentre and focal depth were reported from two different sources as: (a) at 27.35°N 88.35°E, near Ralang (South Sikkim), with a focal depth of 30 km (www.usgs.gov) and (b) at 27.7°N 88.8°E, near Lachung (North Sikkim), with a focal depth of 33 km. The event caused structural damage to built infrastructure in and around the state capital, Gangtok.

Recently, another earthquake of 6.9 magnitude with its epicentre near the India–Nepal border (27.7 N, 88.2 E) was recorded on 18 September 2011 at 18:10 for 47 seconds (IMD 2011). Gangtok, capital city of Sikkim, which is around 58.74 km southwest from the epicentre, experienced earthquake intensity of VI in MMI scale. It caused noticeable damage to infrastructure and caused widespread panic. In Gangtok, many government offices and hospitals were damaged due to this event.

The 18 September 2011 Sikkim earthquake led to several 'new' and a few 'reactivated' landslides around the foothill of Gangtok. Also, moderate to heavy monsoon rainfall prior to the occurrence of 18 September 2011 earthquake partly contributed to lowering the shearing strengths of already loosened (due to earthquake shaking) slope, forming mass and ultimately triggered some landslides at selected locations just immediately after the earthquake shock.

Hydro-Meteorological Hazard
The entire city of Gangtok drains into the two rivers, Ranikhola and Roro Chu, through numerous small streams and Jhoras. Ranikhola and Roro Chu rivers confluence with Teesta River, which is the major source of drinking water to the population downstream. The densely-populated urban area of Gangtok does not have a combined drainage system to drain out the storm water and waste water from the buildings.

Gangtok city has a very good natural drainage network. Floods are not a major hazard in Gangtok city; however, water stagnation can be observed during monsoon due to construction activities and poor maintenance of natural drainage (Jhoras) in city. There were evidences of recent activities initiated by the municipal corporation to bring awareness and initiate pre-monsoon processes for clearing off these drains of debris to enable uninterrupted flow of rainwater through the existing drains. Indications of success from these activities were informed by stakeholders during the consultation process.

Public Health Risks
Water-borne and vector-bone diseases are some Public health risks in Gangtok are currently being managed by the Integrated Disease Surveillance Project (IDSP). The health department is also quite active in addressing the health risks by accessing information from the city health centres at regular intervals, especially during the monsoons. The city

usually faces health problems related to water-borne diseases in comparison to vector-borne diseases.

The bulk of constructions, along with population growth in the town's peripheral, have been generating health risk and morbidity. Much of the water-borne diseases, including diarrhoea, are results of absence of proper sewage disposal system. Waste (solid waste) is discharged into open drains and natural drains, which are sources of drinking water to the city.

The location (altitude) and the climate favour the city and provide unfavourable environment for much of common disease vectors, including malaria and dengue. Nevertheless, in the recent past, cases of dengue were detected within the city. This can be attributed to the migration of people and the infected acting as carriers of previously non-documented diseases to the city.

6.3 BRIEF VULNERABILITY PROFILE

Sikkim has a long history of common practice to build residential buildings using wood/bamboo. Such traditional constructions perform quite well during ground shaking. Most major old buildings in Sikkim are made of stone masonry with mud mortar and are vulnerable to earthquake hazard.

Gangtok, being the capital and tourist destination, has experienced considerable population growth due to migration in the past decade. Lack of building use regulations and enforcement of design regulation for concrete structures has led to the growth of engineered buildings within the city. Further, non-enforcement of planning bylaws and urban development policies has led to large-scale development along vulnerable areas in the recent past. Buildings being constructed over natural drains were evident within the city. Such unplanned development and un-engineered structures in seismically active region with a history of landslide will magnify the population at risk.

The 2006 and 2011 earthquakes caused significant building damage and collapse. Stone masonry buildings suffered substantial damages during the most recent earthquake. Presently, reinforced concrete frame buildings with masonry in fills are mostly used in private as well as government constructions.

Being a mountainous region, lack of paved roads places much of the peri-urban population at risk. In addition, lack of connectivity and communication mechanisms increases the complexity of search and rescue. Currently, there are training, capacity building and coordination programmes, which are being conducted for the volunteering mountaineers. These groups of volunteers did play a significant role in the aftermath of the 2011 disaster. While rescue may be possible, accessibility to health services during disaster event is still an issue of concern.

6.4 INSTITUTIONAL FRAMEWORK

Indian Meteorological Department
The unit of meteorological centre, Gangtok, has a forecasting unit aided by Satellite Data Utilization Centre (SDUC) equipped with Meteorological Data Dissemination (MDD) System. The centre has one Automatic Weather Station (AWS), three Agro-AWS and ten Automatic Rain Gauge (ARG) stations. The centre also uses radiosonde during monsoons for increasing the accuracy of forecast.

The centre is also equipped with High Speed Data Terminal (HSDT) and Very Small Aperture Terminal (VSAT) facilities. Interactive Voice Response System (IVRS) with a toll free number is currently available to provide local weather forecast to the general public.

Daily, the weather forecast information is sent to the key government departments through email/fax. SMS including key weather parameters are sent in case of extreme weather events. The same information is also uploaded on the website for public access. Daily forecast for the city of Gangtok is currently provided, which includes information on temperature and rainfall. District maps indicating heavy rainfall warning are also provided on a daily basis.

Health Department
Health Care, Human Services and Family Welfare Department of Sikkim is the nodal department for all public health warning and forecast for the city of Gangtok. Even though it is a state department, having its headquarters in Gangtok helps in facilitating and coordinating actions for disease

surveillance and containing outbreaks. State Surveillance Unit (SSU) and District Surveillance Unit (DSU), under Integrated Disease Surveillance Project, function under the Health and Family Welfare Department to monitor and take action in events of outbreak.

The district surveillance unit and the state surveillance units are currently well-equipped to communicate information through telephone, fax, internet, EDUSAT and VSAT facilities. Currently the number of health workers for conducting active surveillance within the city is limited and the main source of information is from the inpatient and outpatient records from the government hospitals. The media also plays a critical role in disseminating information regarding areas with possible outbreaks for the health department to take action.

The media of the state are being used to spread the message of prevention and control of water and vector-borne diseases in collaboration with IEC Bureau. The department also provides advisories during pre- and post-monsoon through television and newspapers.

Department of Land Revenue and Disaster Management

Land Revenue and Disaster Management Department is the nodal agency for state disaster management. Apart from providing relief to the victims of disasters, the department is responsible for disaster prevention, mitigation and preparedness and as a nodal agency it has been implementing various disaster management programmes within the state.

Sikkim State Disaster Management Authority (SSDMA) is a part of State Government and is a nodal institution for planning, co-ordinating and monitoring disaster prevention, mitigation, preparedness and management. Over the years, SSDMA has taken initiatives such as mapping and awareness generation. SSDMA has undertaken the mapping of multi-hazard risk and vulnerability profile at state and district levels and awareness campaigns towards prevention and adaptation for high risk events such as landslides, earthquakes and fire.

The department has minimal equipment for post-disaster search and rescue. Forecasting, warning or risk communication equipment or systems were evident while the monitoring and evaluation were conducted. The state and the department currently rely upon central government institutions, including armed forces and local media for forecasting, communicating risk and disseminating warning information.

Urban Local Body

Till recently, Gangtok was not administered by a municipality, but directly by the various departments of GOS, particularly the Urban Development and Housing Department (UDHD) and Public Health Engineering Department (PHED).

Gangtok municipality was recently formed and is yet to assume responsibility of coordinating and managing disaster management functions. The presence of state institutions like SSDMA caters to the city’s needs. The current primary responsibility of the city administration is solid waste management. Even though not directly linked to disaster management, choking of natural drains within the city was cited as one of major problems the city faces during the monsoon. The local body provides awareness and supports the SSDMA in the pre-monsoon preparedness, which includes cleaning of drains.

6.5 INDICATORS OF THE EXISTING CONDITION OF EWS

Table 5: **Criteria development matrix: Indicators of existing condition of EWS in Gangtok**

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)	●	●	●	○	○	State Disaster Management Plan indicates roles and responsibilities of local governments
1.2	Institutional mechanism for local authority (ULB) is an integral part of EWS framework (document, mandate, implementation)	●	○	○	○	○	Select state departments have DM Plan, but these plans are yet to be implemented. The Gangtok City Disaster Management Plan (CDMP) does not clearly highlight the responsibilities of its municipal corporation in providing early warning services
1.3	ULB accorded with the authority to disseminate warnings (mandate, SOP, implementation)	●	●	○	○	○	Gangtok Municipal Corporation came into being recently and its mandate for operations is currently limited to solid waste management. While the role of ULB is realized, the mandate for implementation does not exist and dissemination of early warning information is not formalized
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)	●	●	○	○	○	State departments have disaster management plans. Implementation is limited to adaptation and short-term measures. Resource constraint was quoted as one of the barriers in implementation

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)	●	●	●	●	○	Hotspots identified and mapped across the city for all hazards, not updated at regular intervals. Gangtok Municipal Corporation also has MHRVA for city
2.2	Outreach practice (dissemination of warning)	●	●	●	○	○	Information about events is communicated to all government institutions and media
2.3	Timely dissemination of warnings to vulnerable groups (residing in slums, high risk prone areas)	●	●	●	○	○	Dissemination of warning exists for select hazards, but with limited response time
2.4	Arrangement for night time warning (limited to floods, landslides)	●	●	○	○	○	City stakeholders recognize the need for night time warning, but are yet to prepare an action plan for implementation
2.5	Media engagement in dissemination of warning	●	●	●	○	○	Due to the nature of the terrain, media have limited coverage. Currently, warning information is collected by media from the respective technical and administrative agencies for dissemination. Shortcomings in communication were evident
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)	●	○	○	○	○	Gangtok Municipal Corporation does not have the mandate to provide warning to the general public

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)	●	●	●	○	○	Multi hazard risk is assessed and technical information demarcates risk prone administrative units. Risk assessment products available in the form of maps and quantitative information
3.2.1	Warning mechanism for geophysical hazards (earthquake)	●	○	○	○	○	No warning mechanism currently exists for geophysical hazards
3.2.2	Warning mechanism for hydro-meteorological hazards (cyclone, severe winds, heat wave, cold wave, extreme rainfall, fluvial flooding, pluvial flooding)	●	●	○	○	○	Warning of hydro-met hazards is provided by IMD with limited respite time. Efforts are underway for improving the consistency and reliability of the warning message
3.2.3	Advisory mechanism for public health risks (vector-borne and water-borne diseases)	●	●	●	○	○	General advisory exists with no indication of areas and vulnerable groups. Currently warning messages with respect to public health are provided by the state health department
3.3.1	Availability of technology to nowcast/ forecast geophysical hazards by technical agencies	●	○	○	○	○	The city does not have nowcast/forecast mechanisms for geophysical hazards risk monitoring or forecasting
3.3.2	Availability of technology in nowcast/forecast of hydro-meteorological hazards by technical agencies	●	●	○	○	○	There exists high dependency on national agencies (Met Centre, IMD Regional Centre) for observation, monitoring and forecasting
3.3.3	Disease surveillance system (surveillance coverage, collection method, analysis)	●	●	○	○	○	State health department has sufficient technology to observe, monitor and nowcast at regional level/district level. Surveillance exists at city level within government hospitals (using paper-based forms) and analysis is undertaken at city level
3.4	Uncertainty in forecast and warning (hydro-met, public health)	●	●	●	●	○	Warning based on forecast for hydro-meteorological hazards exists with medium degree of uncertainty. In case of public health, warnings are provided on realization of an outbreak

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	●	○	○	○	○	Budget head for EWS does not exist within Gangtok Municipal Corporation
3.6	Data availability for operations of EWS	●	●	○	○	○	Data availability for EWS is limited and available with regional and national institutions. The data are partially digitized and are not updated regularly
3.7	Staffing and capacity within local authority for operation and maintenance of EWS	●	○	○	○	○	No dedicated staff for EWS
3.8	Use of modern technology to disseminate warning (hydro-met, public health)	●	●	●	○	○	Use of modern technology (mobile SMS) to disseminate hydro-meteorological and public health hazards was evident. In addition, presence of PAS, siren, digital display, satellite phones and ham radios were evident. The use of the same is currently limited
3.9	Redundancy (multi-mode) in communication networks	●	●	●	●	○	Warning system reflects the arrangement, partially developed, but scope for considerable improvement exists
3.10	City Emergency Operations Centre (EOC) for housing data of hazard, vulnerability and risk	●	●	●	○	○	EOC established with limited technical and human resource support, no information on hazard/vulnerability and risk, activated on a need basis

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	●	○	○	○	○	Generalized warnings from technical agencies such as IMD exist
4.2	Raisng awarenss about warnings at city level	●	○	○	○	○	Efforts are being made to sensitize citizens on frequent hazards such as landslide, maintenance of natural drains (jhoras)
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 not undertaken
4.4	Risk communication	●	●	●	○	○	Local risk assessment has been undertaken (MHRVA) and communicated (threat and associated safety measures) to limited stakeholders. Dissemination is not comprehensive

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	●	○	○	○	○	Links exist, communication is limited to select agencies. In case of hydro-meteorological hazards, IMD sends information to the District Collector for action. In case of public health hazards, IDSP sends information to the District Surveillance Officer
5.2	Extent of links between disaster management agencies and service providers	●	●	○	○	○	Disaster risk awareness and early warnings are currently managed by the district and state departments. However, select service providers are informed only during the onset of an event
5.3	Extent of links between media and disaster management agencies	●	●	○	○	○	Limited information is provided to media before or during an event

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	●	○	○	○	○	Only key staffs in ULB are aware of select early warnings, but impact not clear to initiate action
6.2	Extent to which the warning mechanism allows for feedback from the affected area	●	○	○	○	○	No feedback mechanism currently exists
6.3	Level of reflection and learning evident within local authority	●	○	○	○	○	Post-event reflection is done and change evident in mode of communication
6.4	Monitoring, evaluation and targets for improvement of EWS	●	○	○	○	○	No formal procedures to monitor the performance are currently in place

6.6 SUMMARY

Gangtok, being the state capital of Sikkim, has SSDMA, Land Revenue and Disaster Management Department, Irrigation and Flood Control Department. However, ULBs has limited interaction with national-level technical agencies.

GMC, which was very recently formed by State Urban Development Department, is only looking after Solid Waste Management (SWM) in the city. Early warning and disaster management activities are managed by SSDMA through District Collector of East District (headquarters in Gangtok). IMD has established a meteorological centre in the city of Gangtok. This centre provides early warning on heavy rain and thunderstorm to the District Collector's Office and state departments such as agriculture, revenue etc. The District Collector's Office passes on this information to the general public using PAS. The city also has 24X7 Emergency Operation Centre at MG Road, which is run by the District Collector Office. State Health Department and IDSP give recommendations to the general public on vector- and water-borne diseases.

GMC came into being recently and its mandate for operations is currently limited to solid waste management. State Disaster Management Plan indicates roles and responsibilities of local governments. Select state departments have DM Plan but these plans are yet to be implemented. While the role of ULB is realized, the mandate for implementation does not exist and dissemination of early warning information is not formalized. Much of the state departments have disaster management plan. Implementation is limited to adaptation and short-term measures. Resource constraint was quoted as a main barrier in realizing implementation.

The SSDMA has a range of products, which indicate their efforts towards sound disaster management practice, including preparation of Multi Hazard Risk and Vulnerability Assessment of Gangtok Municipal Corporation Area and Multi Hazard Risk and Vulnerability Assessment of North, East, West and South Sikkim. Hotspots are identified and mapped across them, but are not updated at regular intervals.

Dissemination of warning exists for hydro-meteorological and public health hazards by IMD and health department respectively with limited respite time. Due to the nature of the terrain, media has limited coverage. Currently warning information is collected by media from the respective technical and administrative agencies for dissemination. Shortcomings in communication were evident. City stakeholders recognize the need for warning, especially night time warning, but are yet to prepare an action plan for implementation.

There exists high dependency on national agencies (Met Centre, IMD Regional Centre) for observation, monitoring and forecasting. Efforts are underway by IMD to improve the consistency and reliability of the warning message. For public health, general advisory currently exists with no indication of areas and vulnerable groups. The city does not have nowcast/forecast mechanisms for geophysical hazards risk monitoring or forecasting. State health department has established a mechanism under IDSP to observe, monitor and nowcast disease outbreaks at regional/district levels. Surveillance exists at city level within government hospitals (using paper-based forms) and analysis is undertaken at city level.

Warning system reflects the arrangement partially developed, and scope for considerable improvement exists. State EOC has been established post recent disaster events, especially earthquake. The EOC lacks technical and human resource support and is activated only on a need basis. Use of modern technology (mobile SMS) to disseminate hydro-meteorological and public health hazards was evident. In addition, presence of PAS, siren, digital display, satellite phones and ham radios was evident. But, their use is currently limited. With no dedicated budget for the owning and operating of EWS, both the state and city are limited from deploying dedicated staff to manage the system on a day-to-day basis.

User needs, while realized, have not been assessed. Initiatives for the development of training materials and awareness building were evident. Local risk assessment has been undertaken (MHRVA) and communicated (threat and associated safety measures) to limited stakeholders. Efforts are also being made to sensitize citizens on frequent hazards such as landslide, maintenance of natural drainage (jhoras). A comprehensive dissemination plan is required to support the ongoing efforts.

The current communication, including SMS on risk events, is limited to select agencies. In most cases, these systems are active post event and do not provide action points for pre-event preparedness or coordination. Due to the nature of the terrain and connectivity problems, the role of media is limited in providing warning information.

Post-event reflection is done and change is evident in the mode of communication. Only key staffs in ULB are aware of select early warnings and the impact, but are not clear on initiating action. Formal procedures to monitor the performance, including the roles of respective departments for initiating the warning and translating it to on-ground action will help strengthen the existing mechanisms.

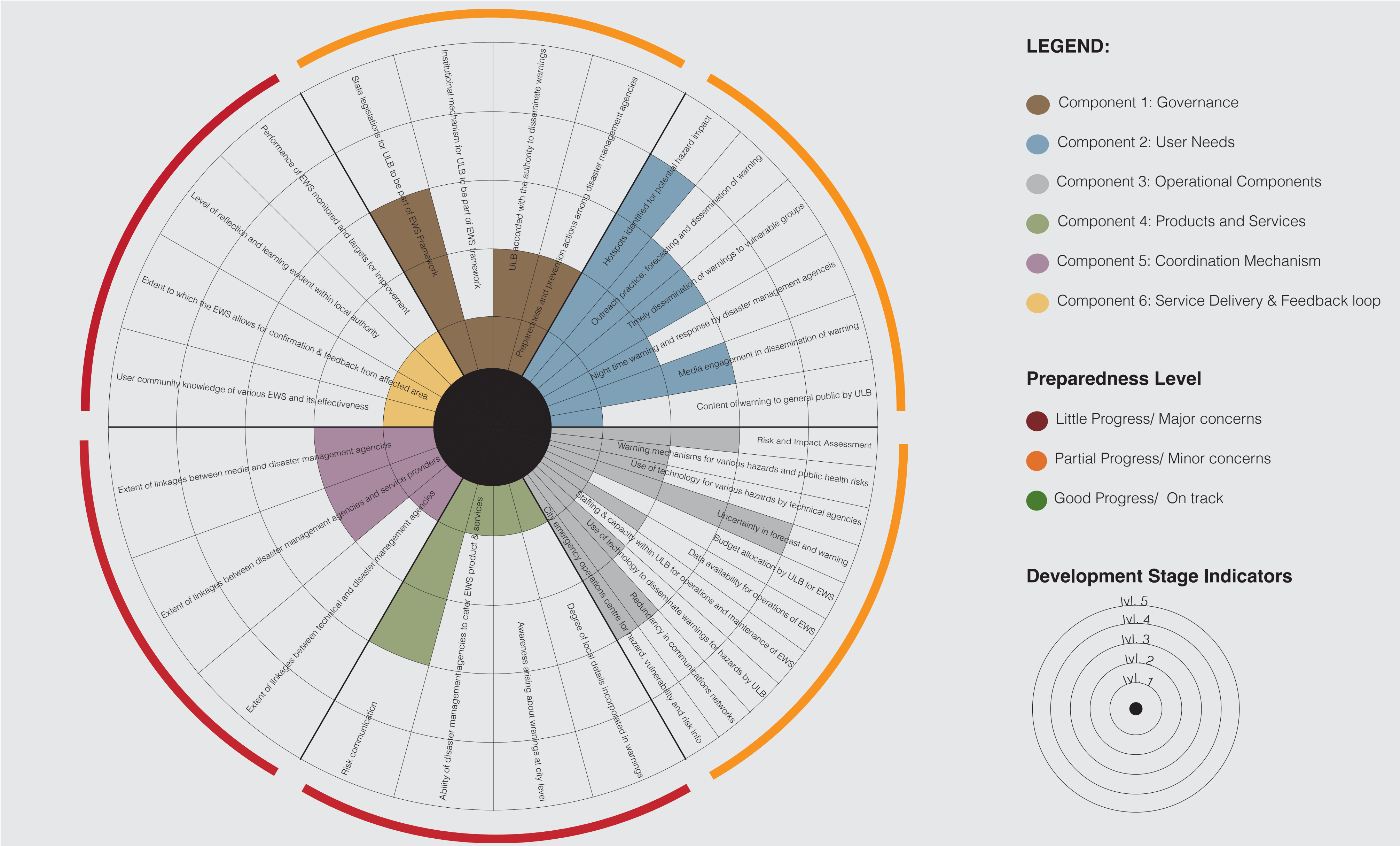


Figure 14**: Preparedness of EWS indicators for Gangtok**

MADURAI

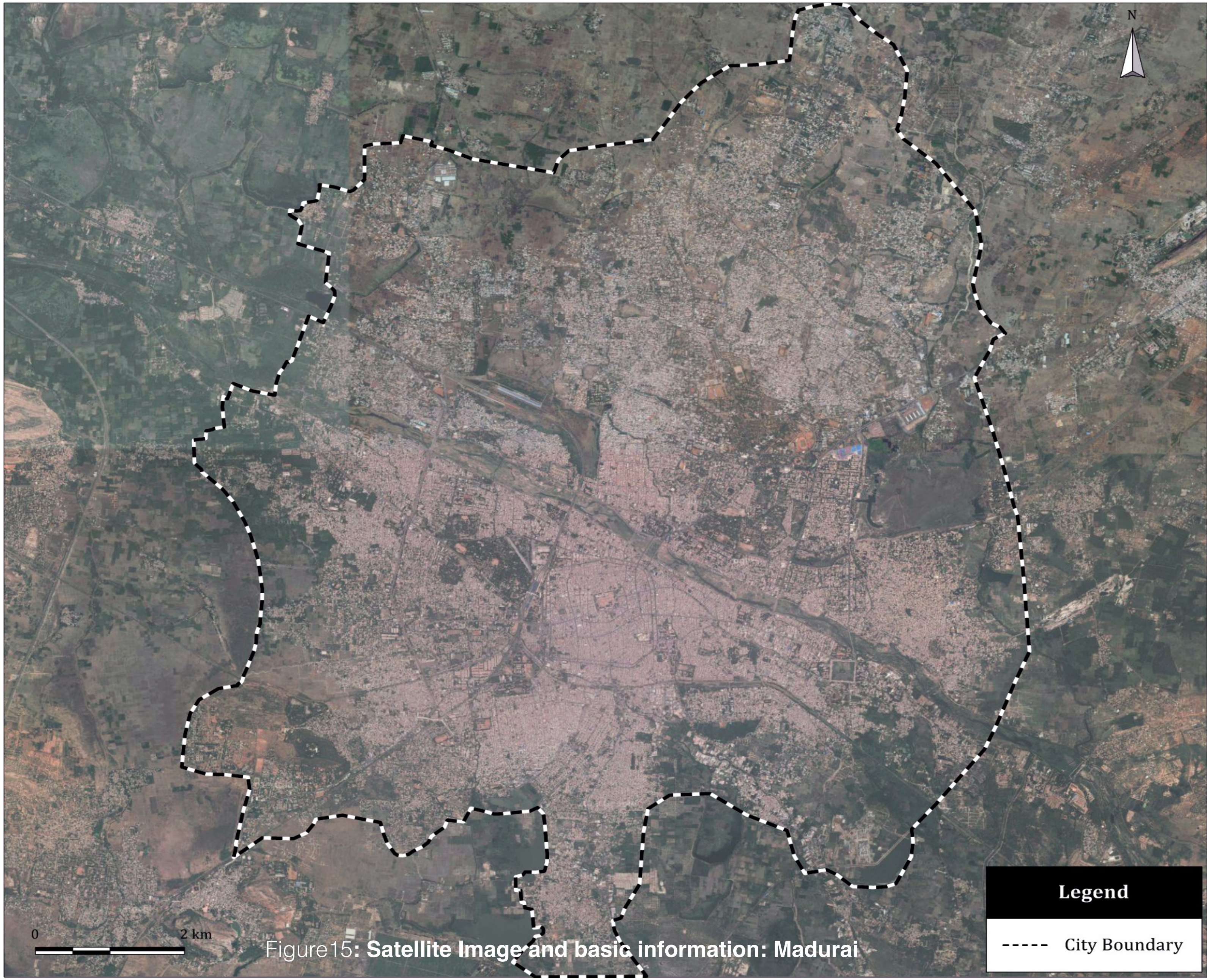
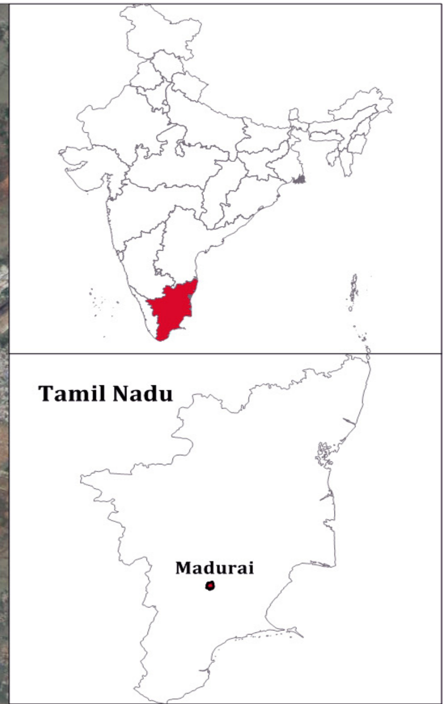


Figure15: **Satellite Image and basic information: Madurai**



Notes:

City	Madurai
District	Madurai
Area	59.96 Sq. Km.
Height from Sea Level	101 Mtrs.
Population	1.01 Million (as per 2011 census)
No. of Wards	72

Key Hazard:
Cyclone, Pluvial Floods, Fluvial Floods
Dengue

Sources:
Census of India, 2011
Madurai Municipal Corporation, 2014
GeoEye Imagery; Google Earth Pro 2014,

7. REVIEW OF EWS IN MADURAI

7.1 GENERAL CITY INFORMATION

The temple town of Madurai is situated on the bank of Vaigai River. Madurai is the third largest city in Tamil Nadu. The Vaigai River flows through the city. The city is surrounded by small and prominent hills, namely, Anaimalai, Nagamalai, Pasumalai and Sikandearmalai.

The climate of Madurai town is hot and dry and the temperature ranges between a maximum and minimum of 42 OC and 21 OC respectively. April and May are the hottest months. Rainfall is irregular and intermittent, with an average of approximately 850 mm per annum.

7.2 BACKGROUND ON HAZARD RISK

Geophysical Hazard

The seismic hazard map of India was updated in 2002 by the Bureau of Indian Standards (BIS). According to the new map, more areas of Tamil Nadu are susceptible to damage from earthquakes. Madurai city is under low damage risk zone [MSK VI]; however, moderate risk will be there in case a major and heavy magnitude earthquake strikes at the nearby districts.

Small to moderate earthquakes have occurred in the state. The frequency of earthquakes is low, i.e., the gap between moderate-sized events is fairly long. Seismic activity in the recent past has occurred in clusters along the borders with Andhra Pradesh, Karnataka and Kerala. Several faults have been identified in this region out of which many show evidence of movement during the Holocene period. The east–west trending Cauvery Fault, Tirukkavilur-Puducherry Fault and Vaigai River Fault and the north–south trending Comorin-Point Calimere Fault and Rajapatnam–Devipatnam Fault are some of them and run close to major urban centres like Coimbatore, Madurai, Nagapattinam, Thanjavur and Puducherry.

However, it must be stated 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.

Hydro-Meteorological Hazard

Floods are among most common hydro-meteorological hazards observed in Madurai city. Madurai city experiences both riverine as well as urban flooding.

Vaigai River, flowing through the city, is the main source of water supply and irrigation. The river originates in the Periyar Plateau of the Western Ghats range, and flows northeast through the Kambam Valley, which lies between the Palani Hills to the north and the Varushanad Hills to the south. The river empties into the Palk Strait in Ramanathapuram District. The Vaigai is 258 km long, with a drainage basin 7031 sq km.

Heavy rainfall from North-East monsoon, which sets in between October and November, sometimes leads to flood situations within the city. Last recorded flood in Madurai city was in the year 1993. During that time, inflow of water to Periyar and Vaigai exceeded the limit due to heavy rainfall on 11 September 1993 (241 mm). Excess water was released from the reservoir (Sathaiyar Dam) within a short duration, causing floods in the city.

The tanks were breached due to excessive inflow (55,000 cusec) of water. Areas like Sellur, Koodal Nagar and Gomathipuram were badly affected. Though the encroachments along Vaigai river were evicted, bund water entered into the city due to breach of Sellur tank.

Madurai city falls under the moderate risk zone of cyclone. But, depressions or cyclonic formation in Bay of Bengal results in heavy rainfall within the region.

Public Health Risks

Madurai is prone to vector-borne diseases such as dengue, malaria and chikungunya (CRME, 2013). Pre-monsoon entomological surveys (2012, 2013) revealed that as many as 20 locations in the city are vulnerable to the outbreak of dengue and other mosquito-borne diseases. Coconut shells are very common breeding grounds for mosquitoes in Madurai.

A master plan for a mosquito-free Madurai has been prepared by the Centre for Research in Medical Entomology (CRME), a premier research institute of ICMR. Mosquito breeding pattern, mosquito bites, water sources and drain systems in Madurai were studied in detail. The master plan was prepared under the guidance of a scientific advisory committee, which monitored the data collating process and finalized the report to eliminate mosquito breeding sources in an effective manner.

7.3 BRIEF VULNERABILITY PROFILE

Historically, Madurai city has been an important trading centre for handloom, silk weaving, pottery, leather industry, etc. However, the significance of trade and commerce has reduced over a period of time due to its vulnerability to floods. Sellur area (within Madurai city) which had more than 10,000 handlooms was severely affected during the 1993 flood. Since many handlooms were not insured, the industry suffered huge loss.

Madurai is also a city of touristic importance for both domestic and foreign tourists and maintains significance as a major tourist destination in India. Presently, the economy is heavily dependent on tourism business. The total floating population of Madurai is estimated to be around 2,10,000 visitors per day (CDP, Madurai). The inflow of foreign tourists peaks during the period from November to March and that of domestic visitors peaks from April to June.

7.4 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. Being a tier two city in Tamil Nadu, all major technical and forecast institutions such as IMD, CWC and GSI have their establishment in Chennai.

Madurai Municipal Corporation(MMC)
MMC is the second oldest municipal corporation in Tamil Nadu, after Chennai.

It consists of a legislative and an executive body. The legislative body is headed by the city mayor while the executive body is headed by the Chief Commissioner. MMC has well-established wireless network to reach its officials. In order to improve the communication system, the Corporation has introduced wireless system and has provided mobile sets to officers at ward and division levels. Wireless handsets are provided to all officials of corporation, including those at the zonal level.

MMC receives warning related to extreme weather from the District Collector's Office and it has City Disaster Management Plan.

The health department of MMC is headed by City Health Officer, and is responsible for ULB services such as solid waste management, public health related works like dengue and malaria control, family planning, mother and child health care, birth and death registration etc., and other government assisted programmes related to health and poverty reduction and awareness programmes. The City Health Officer, assisted by the Health Inspectors and Sanitary Inspectors, is responsible for services of solid waste management and malaria control activities. Junior officers are in-charge of executing work at the field level, which includes monitoring and supervising the work of sanitary labourers in the wards under their charge and attending to specific local complaints. Besides, this department is responsible for the enforcement of the Public Health Act.

The City Health Officer is assisted by the assistant health officer, assistant nurses, biologist and drivers etc. The department is also involved in the promotion of health awareness programmes and implements various state and central assisted schemes like pulse polio project, SJSRY etc.

Integrated Disease Surveillance Project (IDSP)
The State Surveillance Unit (SSU) of IDSP is functioning from the Directorate of Public Health and Preventive Medicine at Chennai. The Joint Director of Public Health and Preventive Medicine (VBDC) is the State Nodal Officer for IDSP.

Irrigation Department
Irrigation department comes under Public Works Department, which executes and maintains all the irrigation projects such as dams, canals, tanks and multifarious works such as construction of buildings, roads, bridges, culverts, water harvesting structures, implementation and maintenance of water supply in rural areas. Irrigation department in Madurai receives warning information from the District Collector Office.

Centre for Research in Medical Entomology (CRME)
Madurai-based CRME is a premier laboratory of the Indian Council of Medical Research (ICMR) with distinguished research work in the prevention and control of vector-borne diseases. CRME closely works with Madurai Corporation on health research.

NGO (DHAN Foundation)
DHAN Foundation is a national level NGO with head office at Madurai. They are currently helping the city government prepare the CDP, heritage development plan and future proofing of water bodies within the city. They also conduct awareness programmes within the city.

7.5 INDICATORS OF THE EXISTING CONDITION OF EWS

Table 6: **Criteria development matrix: Indicators of existing condition of EWS in Madurai**

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)	●	●	●	○	○	District Disaster Management Plan highlights the responsibility of ULB. Madurai Corporation is a member of District Disaster Management Committee
1.2	Institutional mechanism for local authority (ULB) is an integral part of EWS framework (document, mandate, implementation)	●	○	○	○	○	The city disaster management plan indicated the role and responsibility of all departments within its jurisdiction. The state and district DM plan highlights preparedness, but does not include SOP for technical and other agencies
1.3	ULB accorded with the authority to disseminate warnings (mandate, SOP, implementation)	●	●	●	○	○	The need to institutionalize early warnings and disaster management within the municipality is evident from the district and city disaster management plans. Institutionalization and integration of the processes are yet to be realized
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 within the municipality are currently responsible for providing select warnings, e.g., Health department and PRO are given the responsibility of informing the public. A majority of the warnings is disseminated through District Collector Office

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)	●	●	●	○	○	Based on historical events, hotspots for floods such as low lying areas and rehabilitation centres have been identified and mapped
2.2	Outreach practice (dissemination of warning)	●	●	●	○	○	Madurai Corporation receives warning from District Collector's Office in event of cyclonic winds, extreme rainfall and floods. Upon the receipt of warning, the corporation informs people at risk within its jurisdiction
2.3	Timely dissemination of warnings to vulnerable groups (residing in slums, high risk prone areas)	●	●	●	●		Dissemination of warning exists for cyclone, floods and disease incidences with limited respite time. The dissemination of warning is generally done using vehicle mounted PAS
2.4	Arrangement for night time warning (limited to floods, landslides, cyclones, tsunamis)	●	○	○	○	○	No specific arrangement was evident within the city for night time warning
2.5	Media engagement in dissemination of warning	●	●	○	○	○	PRO is responsible for informing broadcasting agencies, including newspaper/local media regarding flood warning. Coverage and communication require strengthening
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)	●	●	○	○	○	Health department and PRO of Madurai Corporation currently provide warning and advisories during rainy months

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)	●	●	●	○	○	City level risk not assessed, however, hotspots (low lying areas) identified and mapped based on past events
3.2.1	Warning mechanism for geophysical hazards (earthquake)	●	○	○	○	○	Madurai city is not in seismically active zone (Zone II)
3.2.2	Warning mechanism for hydro-meteorological hazards (cyclone, severe winds, heat wave, cold wave, extreme rainfall, fluvial flooding, pluvial flooding)	●	●	●	○	○	Consistent warning message is provided by PWD/DC office to ULB and ULB to city for severe winds, extreme rainfall and floods. No warning mechanism currently exists for heat waves and pluvial floods
3.2.3	Advisory mechanism for public health risks (vector-borne and water-borne diseases)	●	●	●	○	○	Health department issues general health advisories during monsoon months
3.3.1	Availability of technology to nowcast/ forecast geophysical hazards by technical agencies	●	○	○	○	○	The city is not at high risk to earthquake, landslide and tsunami. Therefore, there is high dependency on national agencies for observation, monitoring and forecasting
3.3.2	Availability of technology in nowcast/forecast of hydro-meteorological hazards by technical agencies	●	●	○	○	○	High dependency on IMD and PWD for observation, monitoring and forecasting at regional level
3.3.3	Disease surveillance system (surveillance coverage, collection method, analysis)	●	●	●	●	○	Monitoring of health information at city level is being carried out by the health department. It is sufficiently equipped to carry out syndromic/disease surveillance
3.4	Uncertainty in forecast and warning (hydro-met, public health)	●	●	●	●	○	Forecast exists with minimal attention to dissemination of warning in case of extreme winds and floods. Advisories are provided in case of public health upon realization of an outbreak

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	●	○	○	○	○	Budget head for EWS does not exist
3.6	Data availability for operations of EWS	●	○	○	○	○	Select data for operation of EWS at regional level is available with IMD and PWD. There is no availability of river gauge, dam release, rain gauge or weather station data with ULB for design and operation of EWS
3.7	Staffing and capacity within local authority for operation and maintenance of EWS	●	○	○	○	○	No dedicated staff for operation of EWS currently exists
3.8	Use of modern technology to disseminate warning (hydro-met, public health)	●	●	○	○	○	Use of modern technology was not evident. In addition to generic media, public addressal system (PAS) is in place. The municipal corporation also uses wireless handsets to communicate. Health department publishes advisories in newspapers. It also uses wireless to communicate/ coordinate with the team
3.9	Redundancy (multi-mode) in communication networks	●	●	●	●	○	Apart from mobile phone, landline phone and fax, Madurai Corporation officials are well equipped with wireless handsets to ensure redundancy
3.10	City Emergency Operations Centre (EOC) for housing data of hazard, vulnerability and risk	●	●	○	○	○	Need for establishment of EOC has been recognized, but action is yet to be initiated on ground.

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	●	●	●	○	○	Exists only for pluvial floods and public health. Madurai Corporation provides warning to communities which are highly exposed to the hazard
4.2	Raisng awarenss about warnings at city level	●	○	○	○	○	Awareness programmes are limited to public health only
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 not undertaken
4.4	Risk communication	●	●	●	○	○	Low lying areas and slum locations have been identified. These areas are targeted for risk communication in events of floods and disease outbreak

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	●	●	●	○	○	Links exist between technical agencies and disaster management agencies with limited coordination mechanism
5.2	Extent of links between disaster management agencies and service providers	●	●	○	○	○	Formal links do not exist
5.3	Extent of links between media and disaster management agencies	●	●	○	○	○	Media predominantly depend on information hosted on public domain. In addition, PRO provides additional information as and when need arises

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	●	●	○	○	○	Madurai Corporation and District Health Officials have stronger links and are aware of the advisories. Instances of coordinated actions were evident in events of disease outbreak. No awareness on the impact and evidence of coordinated actions exists in events such as heat waves and pluvial floods
6.2	Extent to which the warning mechanism allows for feedback from the affected area	●	○	○	○	○	No feedback mechanism established
6.3	Level of reflection and learning evident within local authority	●	○	○	○	○	Post-event reflection is done and change evident in mode of communication
6.4	Monitoring, evaluation and targets for improvement of EWS	●	○	○	○	○	No formal procedure to monitor the performance is in place

7.6 SUMMARY

Madurai is tier two city in Tamil Nadu, which has very limited link with state and national level early warning and disaster management agencies. The city of Madurai has limited exposure to hydro-met and geological hazards. Flood is considered to be a threat to the city. The last recorded major flood in Madurai city was in the year 1993. Forecast for hydro-met hazards (heavy rainfall) is currently provided by IMD Regional Met Office, Chennai, to State Relief Commissioner. District Collector receives warning from State Relief Commissioner. Madurai is highly vulnerable to vector-borne diseases such as dengue, malaria and chikungunya. In recent years, dengue has emerged as one of the major diseases in the city and the surrounding regions.

Vulnerability is very high due to floating population. Madurai is a city of tourist importance; both domestic and foreign tourists visit the city. The economy is mainly dependent on tourism business.

Madurai district and city have their respective Disaster Management Plans. As per District DM Plan, Madurai Corporation is a member of District Disaster Management Committee (DDMC). Roles and responsibilities are clearly mentioned in the city disaster management plan. Department of Madurai Corporation has been assigned the task related to early warning.

Public Relation Officer (PRO) of Madurai Corporation is responsible for informing the public in low lying areas for evacuation and providing shelter in the corporation in areas identified as safe. PRO is also responsible for issuing flood warning through newspapers, television and other media. PRO makes arrangement to broadcast public address through the Mayor and/or Commissioner.

As per City DM Plan, Health Department of MMC is assigned to issue warning to people residing in low lying areas by the Vaigai river side and also advise them to move to safer locations (towards high rise area); communicate flood warning to people with the help of public address system (PAS); broadcast flood warning information through radio and television.

MMC also receives three levels of warning from PWD (Irrigation Department) through Collector Office. This warning is related to water level in Vaigai reservoir and water release from the reservoir. After issuing the third warning, water is released from Vaigai dam. City Hotline between Indian Meteorological Department and the State Emergency Operation Centre (EOC) is established (in Chennai). Dissemination to the districts is done through telephone and fax. IP phones are also available; they connect the State with the district headquarters, taluks and blocks. Wireless radio network – both high frequency and very high frequency – is available for communication across the state.

MMC is fully dependent on District Collector's Office for hazard based early warning. At the city level, Madurai Corporation has established a wireless communication network. Each officer at the ward level (up to sanitary inspector) is equipped with wireless sets, which helps in a close coordination between implementing agencies.

Local level details are not incorporated in hydro-met forecast/warning, which is currently given by district level disaster management agency to ULB. However, low lying areas have been marked and mapped by MMC. Health Department of Madurai Corporation actively observes the existing situation of public health in the city and also collects relevant data. This information is also provided to state level research institution. Awareness programmes are limited to public health only.

The review of city level key agencies brought the need for early warning system for all hazards to the forefront. Currently, there is no EOC established and operationalized within the Madurai Corporation (ULB) to support EWS or to undertake disaster management initiatives. Hotspots such as low lying areas and shelters have been identified, mapped for flood hazard by Madurai Corporation. Hazard map updating process has not been undertaken and technology such as GIS is not envisaged for the mapping exercise.

The Hazard, Risk and Vulnerability Assessment (HRVA) is at various stages of completion in the city. HRVA data format was prepared and circulated to collect necessary details to assess risk and vulnerability of particular locations. Need for technical analysis dissemination through user friendly formats is realized. Since city level risk assessment has not been completed, critical infrastructures, critical locations, vulnerable population to enable/enhance the mitigation and response delivery mechanism have not been identified. Systematic collection, collation, maintenance and updating of relevant data required to make an effective EWS is limited.

There is no separate budget allocation for creating and operationalizing EWS. However, the ULB is proactive in warning dissemination by using the locally available communication modes (sirens and vehicle mounted PAS).

User needs assessment has not been undertaken by MMC to demand specialized products from technical agencies (like IMD, CWC). The same is true for lack of coordination between technical agencies to make effort to understand local user specific needs to disseminate relevant information.

Coordination between national to state and local level agencies is very important in early warning system. Failure at one level or lack of coordination across them could lead to the failure of the whole system.

Limited formal links except for the protocols defined by the agency's mandate (IMD is mandated/requested to send forecast to specific departments at state and district levels) exists between different agencies in Madurai city. The city level Emergency Operation Centre (EOC) and city disaster management cell are not operational in Madurai. In the absence of EOC, hazard early warning in the city is being conveyed by the state and district agencies.

For hydro-meteorological and geological hazards, the issuance of warnings is the responsibility of technical agencies; however, roles and responsibilities of various state and city stakeholders for implementation of early warning need to be clarified and reflected in the state and city level disaster management plan, regulatory frameworks, planning, budgetary, coordination and operational mechanisms. Coordination mechanism for health hazards is well-established in the city and Madurai Corporation has data/information sharing mechanism with district and state level health research institutions. It is also observed that no direct link is established with local media. Media depend on information hosted on public domain.

Currently, there are no formal feedback mechanisms observed in Madurai city between technical and disaster management agencies, and between ULB and communities at risk. However during annual pre-monsoon meetings, limited discussions are held on the results of actions taken in the previous year. Systematic feedback and evaluation at all levels is needed for determining system efficiency. It helps to understand whether the established mechanisms are able to translate the information gathered to take preventive measures.

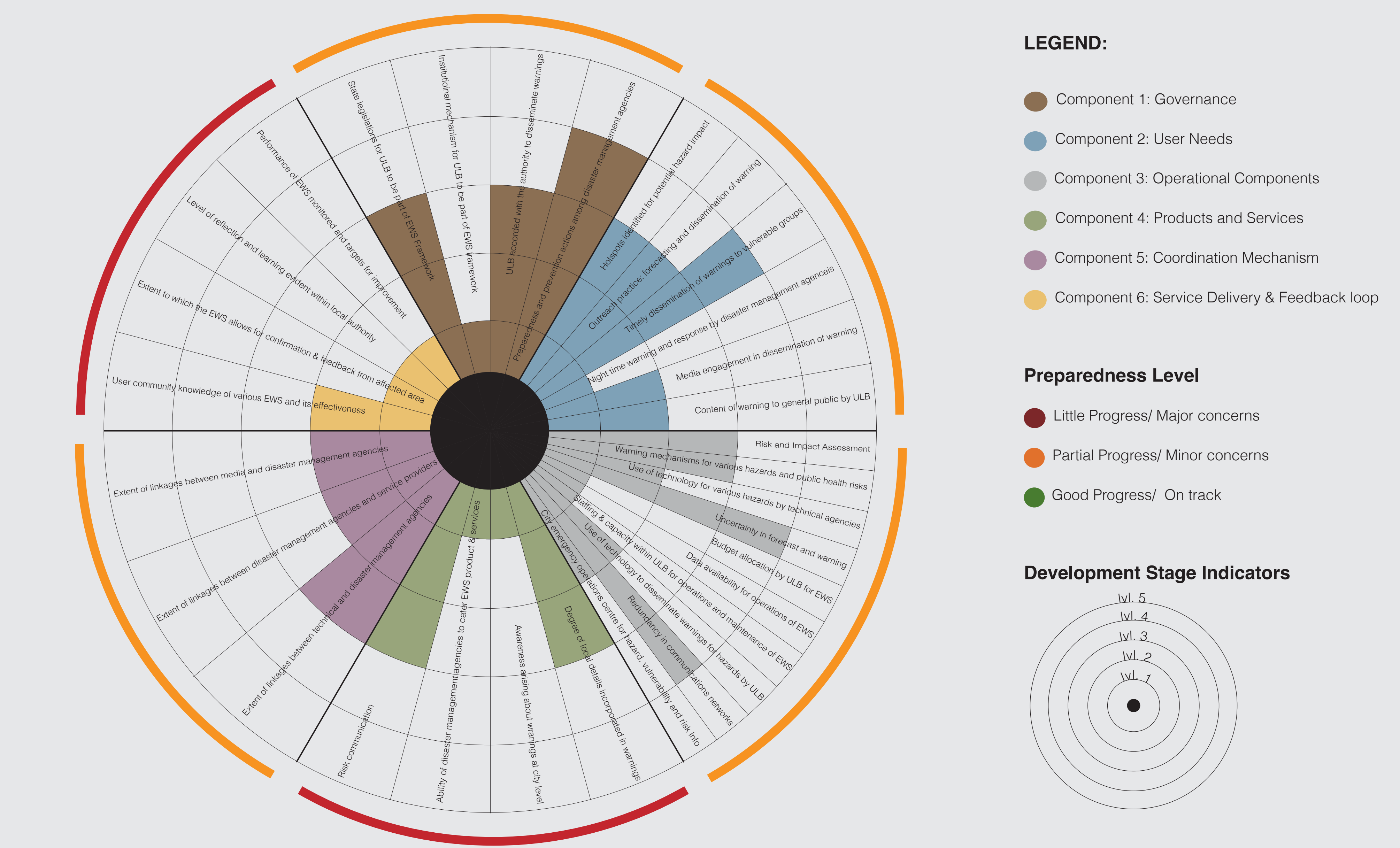


Figure 16**: Preparedness of EWS indicators for Madurai**

NAVI MUMBAI

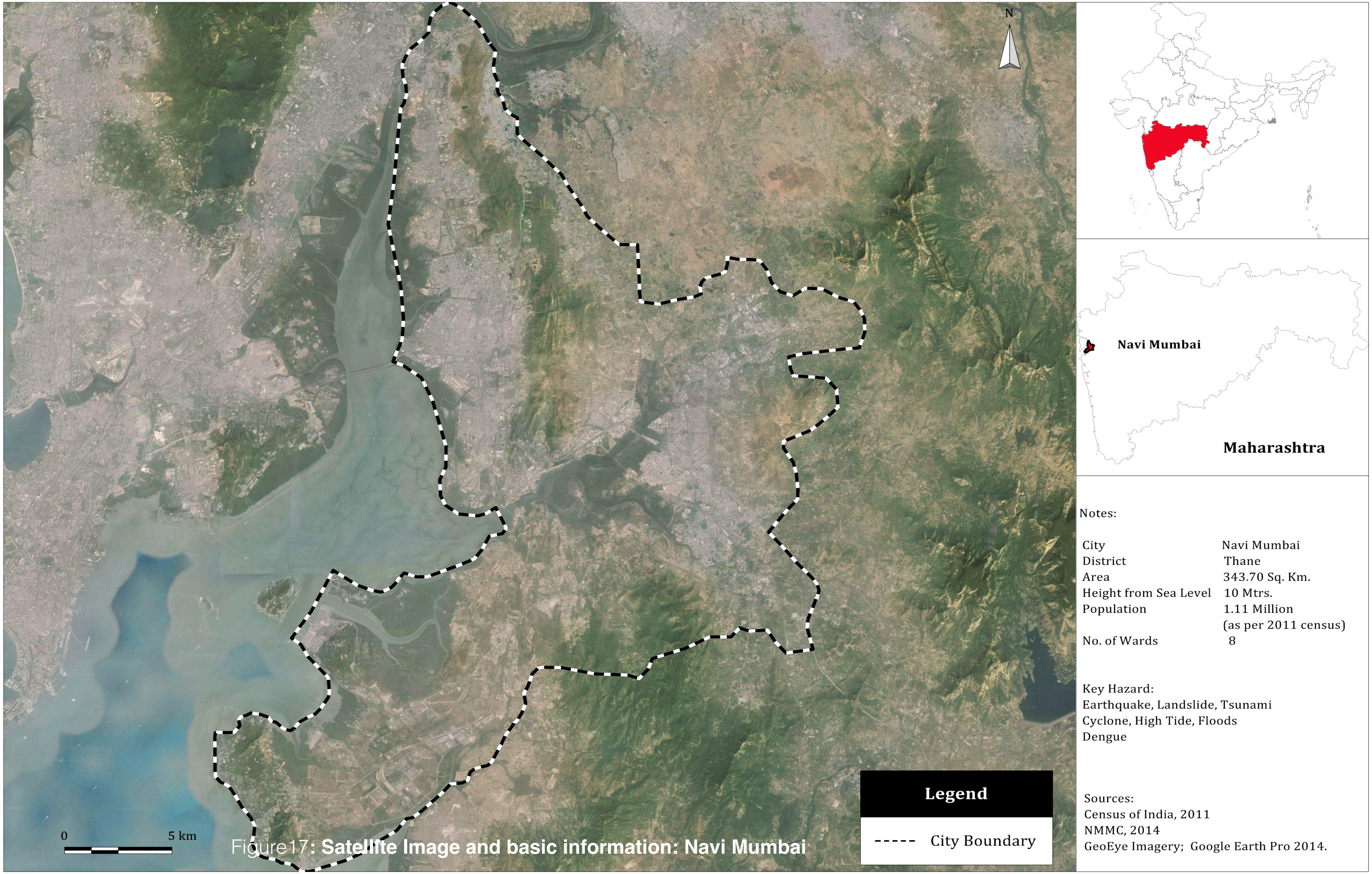


Figure17: **Satellite Image and basic information: Navi Mumbai**

8. REVIEW OF EWS IN NAVI MUMBAI

8.1 GENERAL CITY INFORMATION

Navi Mumbai is a part of South Konkan coastline. This coastline joins Sahyadri mountain ranges in the south and 50 to 100 m high hills in the east. Navi Mumbai lies between mountain ranges and coastline. The city is bounded by Parsik Hill Range and Thane Creek.

Navi Mumbai is located at the centre of Mumbai Metropolitan Region (MMR), surrounded in the west by Arabian Sea while to the north is Thane, to the east is Kalyan and to the south is Panvel town. Navi Mumbai city has been developed by The City and Industrial Corporation of Maharashtra Ltd. (CIDCO) with the objective of reducing the growth rate of population in Greater Mumbai. Therefore, a wholesome planning approach was laid to provide physical and social services to different sections of the population keeping in view the future population growth. Subsequently, developed area within the jurisdiction of Navi Mumbai Municipal Corporation (NMMC) was transferred to NMMC by CIDCO for maintenance, although CIDCO continues to own and develop vacant land within these nodes as the development authority.

Navi Mumbai is a planned city with an area of 162 sq km. Its jurisdiction starts at Digha in the north and ends at Belapur in the south. NMMC area has been divided into eight zones. Sprawling in 108.5 sq km, these zones are Belapur, Nerul, Turbhe, Vashi, Koparkhairance, Ghansoli, Airoli and Digha.

8.2 BACKGROUND ON HAZARD RISK

Geophysical Hazard
Navi Mumbai is located in seismic zone III as per IS:1893-2002 (BIS, 2002) signifying that the city may be subjected to intensity VII damage as per MSK64 intensity scale. A review of the historical as well as recent earthquake activity in coastal Maharashtra indicates that different parts of the region are characterized by low to moderate level of seismic activity (Jaiswal and Sinha, 2006, 2007). As per Seismotectonic Atlas of India (GSI), the West Coast fault is an active fault and runs along the eastern shore of the Thane Creek in the Mumbai area, along the flanks of the Parsik Hills (Belapur–Vashi region). The Chiplun fault runs from the mouth of Bombay Harbour to the Sangammeshwar area in Ratnagiri district.

Landslides in Navi Mumbai occur mainly due to vertical cutting of hills, for construction of houses, roads, railway lines, etc. in Kharghar hills area. The Kharghar hills are part of the Sahyadri hill ranges of the Western Ghats. In absence of proper embankment material, heavy rains lead to falling of earth material and debris. Most cases of landslides occur during heavy rains. Many areas in Navi Mumbai face the risk of landslides due to increased pressure on land. Many vacant sites on hill slopes or bottoms of hills have turned into inhabited area and thereby become vulnerable to landslides.

The western coast of India has not recorded many tsunamis in the past. However, historical events indicate that the coastal region of Navi Mumbai is vulnerable to tsunamis from historical earthquakes which took place along the Makran coast. Navi Mumbai has 25 km long coast and the funnelling effect of Thane creek can increase the risk. In the Persian Gulf, the 1945 Mekran earthquake (magnitude 8.1) generated tsunami of 12 to 15 m height. The estimated height of waves witnessed in Mumbai from the same event was about 2 m, with damages to human lives and boats (Jaiswal and Rastogi, 2007).

Hydro-Meteorological Hazard
Navi Mumbai is around 10 m to 15 m above the mean sea level and parts of the city are on reclaimed land on Arabian Sea coast. The city is bounded by Parsik Hill Range and Thane Creek. Nearly 10 per cent (34.20 sq km of 343.70 sq km) of Navi Mumbai is low lying area unsuitable for development as per development plan of CIDCO. According to Survey of India (SoI) tide table, high tide level with respect to mean sea level is 4.5 m in Navi Mumbai. Due to its geographical location, it experiences inundation and water logging in the low lying areas, during high tides.

Settlements located near Thane creek are in the low lying area and are exposed to high tide, heavy rains (up to 3000 mm) and cyclonic storms leading to flooding. NMMC area experienced 806 mm of rainfall on 26 July 2005, which was the highest. This extreme rainfall resulted in floods causing damage to properties and affecting normal life for a few days. The cyclonic storm, Phyan which crossed Maharashtra coast between Alibag and Mumbai on 11 November 2009 resulted in waves over 2 m high and caused loss of seven human lives and about 44 fishermen went missing.

Public Health Risks
The city is prone to both water-borne and vector-borne diseases. Some of the common outbreaks are of malaria, dengue, hepatitis B and leptospirosis. Being close to the coast, the city experiences high humidity and during summers this, combined with high temperatures during the day, leads to heat-related illness.

8.3 BRIEF VULNERABILITY PROFILE

Navi Mumbai is a planned city. The city is bounded by Parsik Hill Range and Thane Creek. Around 10 per cent (34.20 sq km of 343.70 sq km) area of Navi Mumbai has been declared as low lying area (which is marshy land under tidal creeks). As per disaster management plan of Navi Mumbai, nearly 90 locations have recurring water logging problem during monsoon and 41 slum pockets at various locations get affected. About 181 flooding spots have been identified.

The most important factor that increases the social vulnerability of the city to natural hazards is the city's growing population. To cater to the employment needs of the construction industry, domestic help, trade and commerce, there is evidence of workers migrating to Navi Mumbai. During the last two decades, the population of the city increased from 397,000 to 1,111,320 in 2011 (Census of India). Nevertheless, due to its planned development, the percentage of slum population within the city is relatively lower than in Mumbai.

Navi Mumbai has a pre-eminent position in the state as the commercial and trading base. Also, the Maharashtra Government industrial promotion policy leads to the development of industrial belt in Navi Mumbai. Many government and corporate offices have been shifted from Mumbai to Navi Mumbai. According to CIDCO, there are about 2300 industrial units with an employment of over one lakh with an annual turnover of more than 10,000 crore. Navi Mumbai industrial belt, which is in the jurisdiction of NMMC, has industries such as chemical, pharmaceutical, engineering, textile processing, petrochemical, electronics, oil and processing, paper, plastic, steel and food industries. The exposure of the city to natural hazard may have an impact on the local economy.

8.4 INSTITUTIONAL FRAMEWORK

Navi Mumbai Municipal Corporation
The Navi Mumbai Municipal Corporation (NMMC) manages the disaster situation without intervention from the state authorities, with an EOC and two control rooms. Micro-level plans at zonal level have been prepared for all the eight zones incorporating specific responsibilities of zone officer who will act as Zone Disaster Manager. However, in cases of disasters of exceptionally large magnitude that require coordination with wide range of lateral agencies, including central government agencies, the Additional Chief Secretary (Home) can play a vital role in providing help from various government organizations to the Municipal Corporation to handle the disaster in Navi Mumbai.

NMMC has established Disaster Management Cell at two locations in NMMC area. The functions of the Navi Mumbai Disaster Management Committee are as follows:

- Ensure effective inter-departmental co-ordination between all departments
- Provide policy decisions when required
- Inform government about disaster situation
- Review disaster-related activity reports received from NMMC control room, police control room and army control room, and provide appropriate directions
- Co-ordinate the activities of lateral and central government agencies like Defence Services, SRP, RPF, Coast Guards, Home Guards, CISF, MTNL, Port Trust, FCI, Meteorology Department, MPCB, BARC

NMMC has four AWS and 19 manual rainfall collection spots, which are used in conjunction with the satellite images to add local level information. Hotlines are established between BMC, district collector – Thane and Mantralaya. Three community-based NGOs are connected to the EOC. Local TV and radio channels are used for dissemination of warnings.

IMD Regional Centre, Mumbai
IMD Regional Centre at Mumbai is the principal agency responsible for meteorological observations, weather forecasting, warning and seismology in Maharashtra region. IMD Regional Centre undertakes observations, communications, forecasting, warning and weather services. The centre is also responsible for monitoring tropical cyclone formation in Arabian Sea and carrying out cyclone warning work.

Early warning information (related to heavy rain, high tide, extreme weather including cyclonic events) is regularly being provided by IMD to Disaster Management Unit (BMC), DDMO (Thane) and NMMC by SMS. During monsoon, this information is sent to decision makers such as

District Collector and Municipal Commissioner to take precautionary measures. SMS blasters are used for warning dissemination.

Outreach programmes are conducted by IMD for media to sensitize them on public dissemination of weather-related warnings.

IDSP, Mumbai

IDSP is implemented only in rural areas in the state of Maharashtra. ULBs or cities are not part of this programme. Hence flow of early information from the state to the ULB is not well-established. However, IDSP collects information from Municipal Corporations under Disease Outbreaks/Alerts Reports as per IDSP format.

Revenue Department and State Disaster Management Agency

State Disaster Cell is established under the Relief and Rehabilitation Department of the Government of Maharashtra. State and District Disaster Management Plans are in place. The Emergency Operations Centre (EOC), which was set up in Mantralaya, is being re-established now, post the recent fire accident.

Divisional Control Rooms were set up in divisional headquarters and District Control Rooms in district headquarters. A state-wide communication network was set up, which consisted of VSAT and VHF network. Navi Mumbai city comes in Thane district, Konkan division.

Revenue Department (District Collector)

Regional Disaster Management Centres (RDMC) have been established to set up a first response capacity at the regional level, which can provide support to the urban centres as well as to a number of districts. The RDMC have been established in cities such as Navi Mumbai, Thane, Pune, Nagpur, Aurangabad, Nashik, Sangli, Nanded, Amravati and Solapur. The RDMCs have sufficient capacity to respond to all kinds of disasters and help citizens in saving their lives and property.

District Disaster Management Authority is headed by the District Collector. Thane district collector's office has EOC, which operates 24X7 for natural (heavy rain, floods, cyclone etc.) as well as manmade disasters (fire). Dedicated emergency telephone line, 1077, is in place. Tehsildars, BDOs and all corporations are connected through hotlines.

Vashi Fishermen's Co-Op Soc. Ltd.

No dedicated legislation exists in the state that describes the inclusion of non-governmental organizations or community-based groups in the formal disaster management coordination structure. Informal mechanisms are in place to interact and coordinate for disaster preparedness, response and mitigation. Vashi Fishermen's Co-Op Society is once such community-based organisation working for the welfare of fishermen. Vashi fishermen community receive regular information from the Fisheries Department, Port Authorities, Customs Department and Indian Coast Guards.

In Navi Mumbai, all fishing boats are equipped with wireless stations, GPS and also with Distress Alert Transmitter (DAT). It is a satellite-based emergency warning system, which transmits emergency signal on manual activation. In Navi Mumbai, DAT instruments were provided by the Indian Coast Guards to fishermen to use during any emergency. It receives audio alarm at Maritime Rescue Coordination Centre (MRCC) of Indian Coast Guard with the time of activation, type of emergency, vessel ID and position in sea. Warnings are disseminated to each boat/vessel that is well-equipped with wireless stations, GPS and also with satellite-based emergency warning system: Distress Alert Transmitter (DAT).

IIT Mumbai

IIT Mumbai provides technical support for disseminating daily information on local rain, temperature and other related weather information. MCGM has established a network of 65 AWS across Mumbai. Weather information from these AWS is updated on their website every 15 min.

8.5 INDICATORS OF THE EXISTING CONDITION OF EWS

Table 7: **Criteria development matrix: Indicators of existing condition of EWS in Navi Mumbai**

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)	●	○	○	○	○	The State Disaster Management (DM) Plan has no mention of role/mandate for NMMC as part of the EWS framework. State DMP focus is on District Disaster Management
1.2	Institutional mechanism for local authority (ULB) is an integral part of EWS framework (document, mandate, implementation)	●	○	○	○	○	Navi Mumbai City DM Plan has no mention of EWS
1.3	ULB accorded with the authority to disseminate warnings (mandate, SOP, implementation)	●	●	●	○	○	The dissemination of warnings happens for heavy rains, high tide and disease outbreaks. The information is provided by the Regional Meteorological Department, IMD through SMS (regular interval pre-/during disaster including hotline connectivity). Such warning mechanism from Municipal Corporation is not evident for other hazards
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 actions are evident for heavy rainfall and high tide

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, further supported by limited field checks during heavy rainfall (for landslide hazard)
2.2	Outreach practice (dissemination of warning)	●	●	●	○	○	Forecast exists for weather events and high tide, information is provided by IMD and SOI Tide Prediction Table to government institutions and media
2.3	Timely dissemination of warnings to vulnerable groups (residing in slums, high risk prone areas)	●	●	●	○	○	Warning is disseminated for select hazards and arrangements are made for availability of food and clean water
2.4	Arrangement for night time warning (limited to floods, landslides, cyclones, tsunamis)	●	●	●	○	○	Arrangements are in place for dissemination of warning, 24 h, round-the-clock
2.5	Media engagement in dissemination of warning	●	●	●	●	○	Media add value through display of visual aids, which include location and severity of the event. Local TV/cable channels are involved in warning dissemination
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)	●	●	●	○	○	Health department of Navi Mumbai Municipal Corporation currently provides health recommendations during monsoon months

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)	●	●	●	○	○	City level risk assessment is not undertaken, qualitative ward level hazard indication is provided within the City DM Plan in tabular form (ward-wise number of hotspots for flood/high tide/landslide)
3.2.1	Warning mechanism for geophysical hazards (earthquake)	●	○	○	○	○	No warning and dissemination mechanism currently exists for landslide and earthquakes. The city depends on INCOIS for providing tsunami warnings
3.2.2	Warning mechanism for hydro-meteorological hazards (cyclone, severe winds, heat wave, cold wave, extreme rainfall, fluvial flooding, pluvial flooding)	●	●	●	○	○	IMD Regional Centre at Mumbai is well-equipped. Forecasts and warning are provided by this centre to NMMC
3.2.3	Advisory mechanism for public health risks (vector-borne and water-borne diseases)	●	●	●	○	○	Health department of NMMC currently issues health recommendations during monsoon months
3.3.1	Availability of technology to nowcast/forecast geophysical hazards by technical agencies	●	○	○	○	○	No warning mechanism established
3.3.2	Availability of technology in nowcast/forecast of hydro-meteorological hazards by technical agencies	●	●	○	○	○	IMD Regional Centre at Mumbai is well-equipped with state-of-art instruments, and is able to provide forecast and warning
3.3.3	Disease surveillance system (surveillance coverage, collection method, analysis)	●	●	●	●	○	Monitoring of health information at city level is being carried out by Health Department, NMMC
3.4	Uncertainty in forecast and warning (hydro-met, public health)	●	●	●	●	○	Warning based on forecast exists, with medium degree of uncertainty for hydro-meteorological hazards. None exists for earthquake. Forecast mechanism not in place. Warning information is provided upon realization of first outbreak

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 resource allocation in the municipal budget for EWS
3.6	Data availability for operations of EWS	●	●	●	○	○	NMMC has identified low lying areas (water logging areas), flood prone settlements and landslide prone areas
3.7	Staffing and capacity within local authority for operation and maintenance of EWS	●	●	●	○	○	Overseen by staff deputed on need basis, but not specifically trained around EWS operational framework
3.8	Use of modern technology to disseminate warning (hydro-met, public health)	●	●	○	○	○	No technology is used for identification and dissemination of geophysical hazard warning information. Fixed and vehicle mounted PAS with sirens are positioned at various locations for providing hydro-meteorological warning. Health advisory is provided to public at large through local newspapers and local cable TV operators
3.9	Redundancy (multi-mode) in communication networks	●	●	●	○	○	NMMC will shift to a new premises with well-equipped communication system (communicated during the interview in October 2013)
3.10	City Emergency Operations Centre (EOC) for housing data of hazard, vulnerability and risk	●	●	●	○	○	The current set-up is operational throughout the year and is manned with additional human resources during monsoon period

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	●	●	○	○	○	Partially operational for heavy rainfall (19 manual rain gauges are installed to monitor local rainfall variability)
4.2	Raisng awarenss about warnings at city level	●	●	●	○	○	Awareness is spread through distribution of IEC materials in local languages (pamphlet, booklets), cable TV, radio, programmes in schools/colleges/NGOs/general public functions)
4.3	Ability of technical agencies and disaster management institutions to cater their early warning products and services to user-specific requirements	●	○	○	○	○	Products generated for select hazards (hydro-meteorology) catering to selected users (fisher men community), details are provided to undertake actions
4.4	Risk communication	●	●	○	○	○	Risk is not assessed at the city level. Information communicated by technical agency is hazard-specific during the onset of the event and this information is provided to government agencies and media. Except for Vashi fishermen community, there is need for improvement of risk communication within the city

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	●	●				IMD has expressed willingness to coordinate with the ULB to upgrade the hydro-meteorological network
5.2	Extent of links between disaster management agencies and service providers	●	●				Informal link is evident in some line departments like traffic/engineering (road, sewerage) etc. There is scope to formalize this process
5.3	Extent of links between media and disaster management agencies	●	●	●			Reflection of warning information in media products (such as local cable news, FM radio, local newspapers) is evident (daily during the monsoon period)

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	●	●	●	○	○	Exists for only hydro-meteorological hazards and by few selected service providers (traffic police, engineering (road, sewerage))
6.2	Extent to which the warning mechanism allows for feedback from the affected area	●	○	○	○	○	Formal feedback mechanism does not exist. Discussion is held in the monsoon preparation meetings. Feedback is not established with technical agency (such as IMD) and other departments at regional or national levels
6.3	Level of reflection and learning evident within local authority	●	●	○	○	○	City is well-planned (by past learning from Mumbai City). This is evident from the design and development of city infrastructure such as high tide control mechanism by installing holding ponds. However, EWS as a priority area for the city and disaster management function is not in place
6.4	Monitoring, evaluation and targets for improvement of EWS	●	○	○	○	○	Performance monitoring mechanism is not established

8.6 SUMMARY

Navi Mumbai is a newly planned city and much of the city development needs are designed taking into consideration of possible impact of hydro-meteorological disasters. Regulatory mechanisms, like restriction on activities, which can probably trigger an event such as landslide, are in place.
The Maharashtra State Disaster Management Plan addresses planning arrangements only at the district level. Navi Mumbai City Disaster Management plan mainly focuses on the roles and responsibilities during or post disaster. Currently NMMC manages the disaster situation through an EOC and two control rooms. There is no institutional mechanism within the NMMC (ULB) to establish and operationalize EWS.

City is dependent on technical agencies like Regional Meteorological Centre (IMD), INCOIS and Coast Guards for forecast/ information. Currently, the onus of dissemination of warning and response lies with the NMMC (DM Cell) through media and other protocols, which restricts the outreach (time, space and communities at risk). Value addition to the warning received by technical agencies is restricted to visual display (readability). Information sources including satellite cloud cover and locally installed rain gauge stations were evident in NMMC.

City-level risk assessment is yet to be undertaken to enable/enhance the preparedness and response delivery mechanism. Without detailed hazard, vulnerability and risk assessment may limit response actions to target locations and groups/ communities. Systematic collection, collation, maintenance and updating of relevant data are required to strengthen the warning mechanism.

There is no separate budget allocation for creating and operationalizing EWS. However, the ULB is proactive in warning dissemination using the locally available communication modes (sirens and vehicle mounted PAS). Initiative to collect information from the local level is attempted (evident through installation of 19 rain gauge stations). City has an EOC with two control rooms and eight Zonal Officers with specific responsibilities to manage the facilities. The EOC and control rooms are mainly geared for relief operations. EOC is manned by government officials on deputation with the help of supporting temporarily hired staff, which is functional round the year. Capacity (human resources as well as infrastructure) to add value or to improve the delivery mechanism of forecast/ potential impact is yet to be developed.

Active awareness building measures are undertaken for frequent hazards. Local institutions have helped develop customized warning products for fishermen community. The warnings include action points in case of an event and are targeted at hydro-meteorological hazards.

Lack of formal links and feedback mechanism exists between different institutions within the city. Links between local agencies, such as PWD/ engineering – health/traffic, if established, can stage better response and reduce the overhead costs substantially.

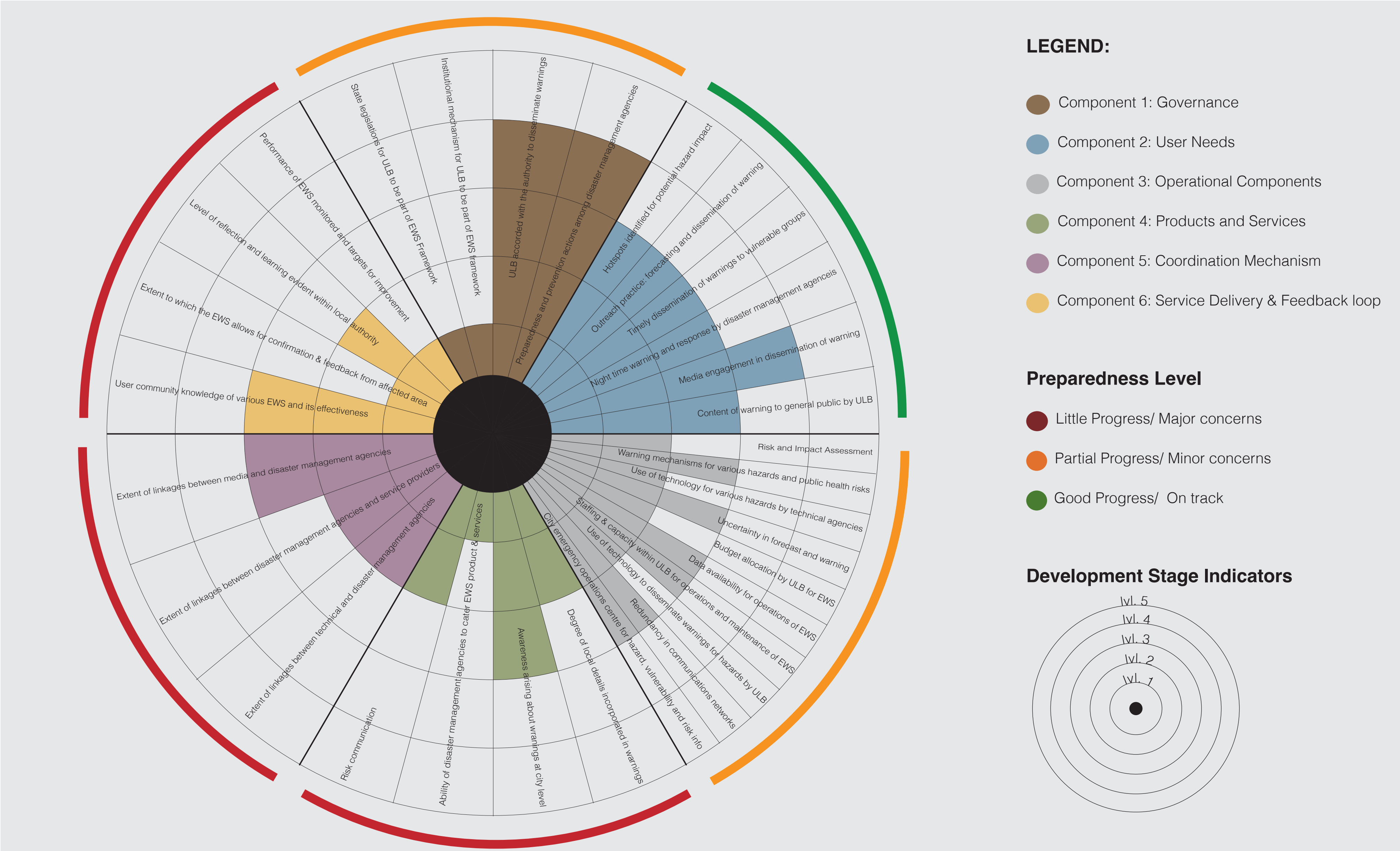


Figure 18**: Preparedness of EWS indicators for Navi Mumbai**

SHIMLA

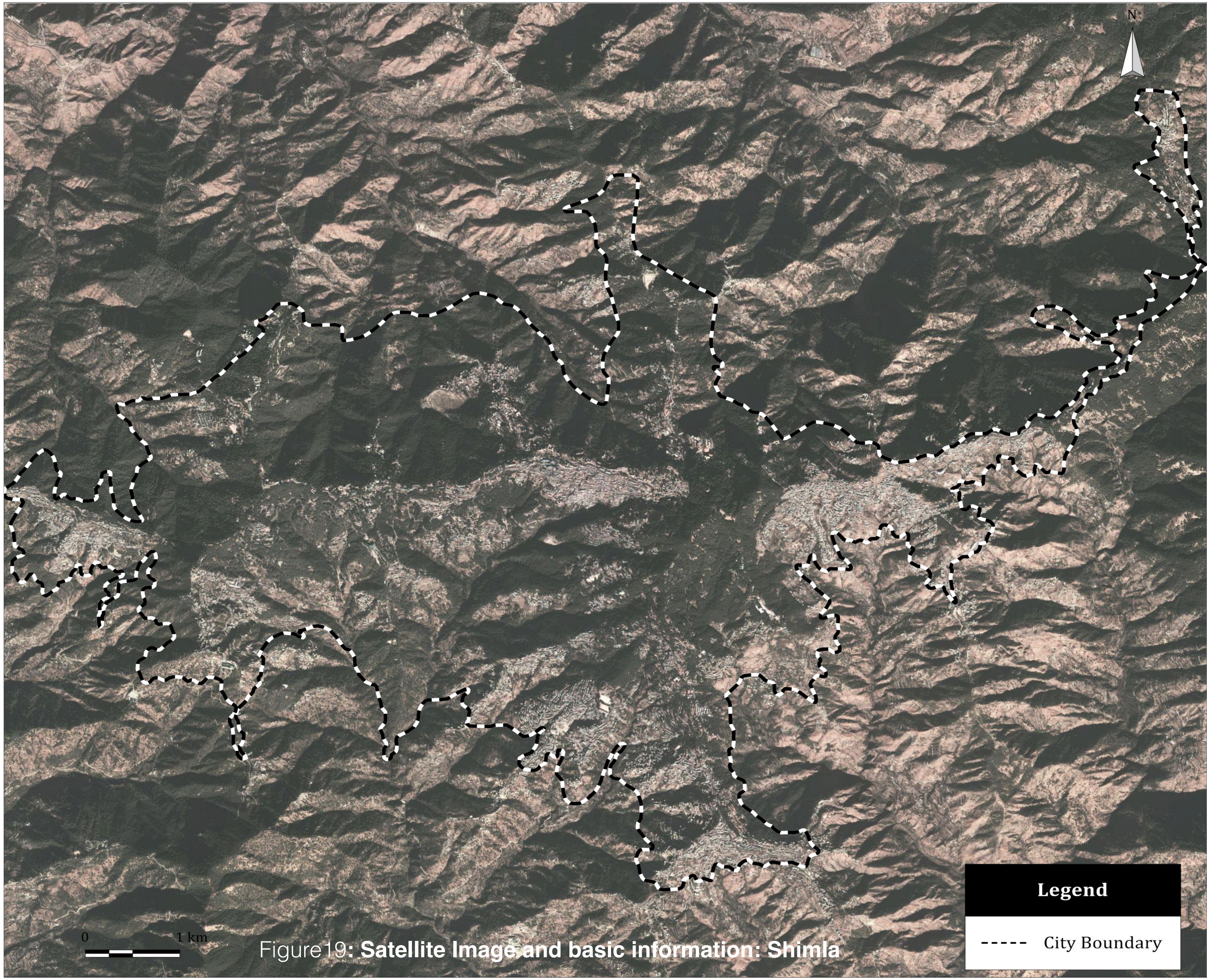


Figure19: **Satellite Image and basic information: Shimla**

Notes:

City	Shimla
District	Shimla
Area	19.99 Sq. Km.
Height from Sea Level	2397.59 Mtrs.
Population	0.169 Million (as per 2011 census)
No. of Wards	25

Key Hazard:
Earthquake, Landslide, Land Sinking
Hailstorm, Severe Storms, including lightning & high winds (Thunderstorms)
Flash Flood/cloud Burst
Heavy Snow Falls

Sources:
Census of India, 2011
Shimla Municipal Corporation, 2014
GeoEye Imagery; Google Earth Pro 2014.

9. REVIEW OF EWS IN SHIMLA

9.1 GENERAL CITY INFORMATION

Shimla city is the capital of Himachal Pradesh and lies in the north-western ranges of the Himalayas. It is located at 31.61°N 77.10°E with an average altitude of 2398 m above mean sea level. The city is spread on a ridge and its seven spurs. The city stretches nearly 9.2 km from east to west.

Shimla city population stands at 169,758 (census 2011); its urban agglomeration population is 171,817 of which 94,797 are males and 77,020 are females. A vast majority of the area occupied by the present-day Shimla city was dense forest during the 18th century. The city was originally designed for a population of 25,000, but today more than 171,000 are residents of the city and the floating population is over 100,000 (especially tourists). The population growth and demand for housing and infrastructure have resulted in rapid and unplanned urbanization of the city.

9.2 BACKGROUND ON HAZARD RISK

Geophysical Hazard
Shimla and its surrounding region are bounded by two major thrusts, the Main Central Thrust (MCT) and Main Boundary Fault (MBF). Other thrusts in the region which include Jwalamukhi Thrust and the Drag Thrust, result in several other lineaments piercing the zone into fractured and faulted blocks and active faults, enhancing the structural discontinuities. The city of Shimla falls in Zone IV (High Damage Risk Zone) as per the seismic hazard zoning map of India. The region has experienced frequent mild tremors and periodic major earthquakes, and this will continue to do so in the future due to its unique tectonic setting. Weak construction techniques and increasing population pose a serious threat to the already earthquake prone region.

Earthquake induced ground failure can be expected along the northern slopes of the ridge, i.e., in Lakkar Bazaar, New Shimla and Vikas Nagar, Ruldu Bhatta, Phingask, Kachhi Ghhati (soft valley), and along the drainage channels. Northern slopes (Snowdown Hospital Area) of the Ridge have already experienced subsidence since 1971 and are still considered as 'sinking zone' extending from Scandal Point to Lakkar Bazaar, including the Old City Bus Stand, Idgah, Longwood, Ruldu Bhatta and adjoining areas. Soft soil depth is about 10 m at some places in New Shimla, which may also lead to subsidence in the face of an earthquake (Anshu Sharma, Reducing Urban Risk through Community-Based Approaches in Shimla; CDMP Shimla 2012).

Another rising concern is the frequent number of landslides that often take place after heavy rains. The other reasons for these slides are faulty building construction practices along these slopes. The city is prone to frequent landslides with majority of the events taking place during the monsoons. Rainfall triggers instability of the slopes, especially after a heavy downpour, resulting in landslide events.

Hydro-Meteorological Hazard
Reports mention that severe storms, lightning and severe winds have in the past caused damage to the city and its infrastructure. The frequent risk includes falling of trees and subsequent blocking of the road network and tripping of electricity and communication networks.

Shimla region also experiences cloudbursts and is prone to flash flood like events. These extreme short-lived events cause severe downpour and wash away all obstacles in the path resulting in loss of lives and severe damage to property.

Snowfall usually occurs between December and February. The CDMP 2012 highlights the Snow Manual, which was prepared for Shimla town and its suburban areas. The objective of this manual is to keep concerned departments in readiness for the snow season, to take such steps as are necessary to prevent damage and loss to human life and property, and to ensure that normal life is restored without any loss of time.

Public Health Risks
Rapid urbanization, industrialization, developmental activities, ecological changes as well as international travel have increased the risk of transmission of diseases. Similarly, changes in lifestyle are accompanied by increased risk of certain non-communicable diseases. Alternatively, inadequate drinking water facilities and poor sanitary conditions pose risk of communicable diseases.

The residents of Shimla are affected by frequent water-borne disease (e.g. jaundice) outbreaks. These outbreaks may be a result of sewage mixing with potable water or contamination of natural water sources. IT also reports cases of acute diarrhoeal disease (cholera), scrub typhus, enteric fever, fever of unknown origin, acute respiratory infection, bacillary dysentery and measles.

The Health Department of SMC and the IDSP Cell undertake IEC activities in regard to safe drinking water, hygienic practices and sanitation measures.

9.3 BRIEF VULNERABILITY PROFILE

Rapid population growth during the last three decades has created a huge pressure on the land due to increased demand for residential housing, commercial activities and urban services. This, combined with poor planning, has resulted in construction of buildings over unstable slopes with little attention to basic safety.

The built environment is very congested and dense, combined with narrow streets and staircases. A large number of the building stock is not accessible by motorable roads. These roads are susceptible to blockages due to landslides (also triggered by heavy rain) or building collapse in the event of an earthquake.

During the peak tourist season, close to 3000 tourist vehicles occupy the roads and cause immense traffic congestion. Lack of open spaces and parking spaces is a major concern in the city. In addition, key lifeline infrastructure of the city, located in zones of high risk, may become inaccessible in case of moderate to high category hazard risk events.

9.4 INSTITUTIONAL FRAMEWORK

The CDMP (2012) outlines the emergency response system for various hazard events and outlines the roles and responsibilities based on the Incident Response System framework as established by NDMA. IRS for Shimla identifies 40 IRS positions and respective officer to man every IRS.

City Emergency Operation Centre is in close proximity to the SMC. In case of an event or a disaster situation, the EOC will serve as a command and control centre of all response activities. Commissioner SMC will assume the role of Incident Commander and activate the command as outlined in the IRS section of the CDMP. About 14 emergency support functions have been identified to cater to response actions in the city. The plan also outlines the role and responsibilities of the primary and secondary agencies.

Select agencies are involved in the process of issuing early warning and coordinating response before and during the events at the city level. Their roles and current functioning based on the available plans and conducted interviews are described below.

Meteorological Centre Shimla
Branch Meteorological Office was set up in Shimla around 1875 and from 1885 onwards, the Indian Daily Weather Report, monthly and seasonal summaries, and long-range forecasts were issued by IMD from Shimla. Meteorological Centre Shimla was established in 2002 by the Government of India, India Meteorological Department (IMD), MoES for providing the meteorological services to Himachal Pradesh. The Meteorological Centre issues weather forecast and severe weather warnings.

Meteorological Centre, Shimla, provides non-aviation weather forecast and adverse weather warnings to the different state authorities/ organizations of Himachal Pradesh. The centre is planning to initiate aviation weather information/ forecast very shortly. The centre also provides agriculture meteorological advisory services for the farmers, seismological services, city weather forecast, tourist forecast, adventure forecast and highway forecast for the state.

The meteorological centre's tasks involve collection of weather data from different observatories in Himachal Pradesh, computation and analysis of surface data, supervision of the work of regular/ part-time observatories situated within the state, monitoring of the data records and strengthening the of meteorological network in Himachal Pradesh. In addition, the centre also responds to the weather-related queries of the state authorities in times of their need.

The centre provides seven day weather forecasts for the city and district-wise agriculture recommendations for the farmers of HP (twice in a week). This information is sent to Commissioners of Relief and other Disaster Management Authorities, District Collectors, Department of Agriculture, Horticulture, Department of Irrigation, Dam Authorities, Railways, Roads and Media. The centre also provides special services to Dam Authorities (BBMB and Ranjit Sagar Dam) and transport (BRO, Beacon, Deepak) departments

The Meteorological Centre of Shimla monitors weather parameters for which forecasts and warnings are issued. This includes rainfall/ snowfall, heat wave/cold wave or events such as hailstorm/thunderstorm and squall. The outreach of forecast is done using SMS. The state through its nodal departments is currently in the process of establishing redundant linkage for sharing real time and online information.

The station at Shimla is equipped with Digital Met Data Dissemination (DMDD) High Speed Data

Terminal (HSDT) and a 256 kbps data circuit for transmission and reception of meteorological data, Interactive Voice Responsive System (IVRS) etc. The Meteorological Office in Shimla has installed the following instruments: thermometers, barometer, rain gauge, thermograph, hair hydrograph, SRRG, Automatic Weather Station (AWS) and Automatic Rain Gauge Station (ARG).

Department of Industries

Department of Industries (Geological Wing) is the nodal agency in the state for mapping landslide risk prone areas and investigating landslide hazard events. The Department of Industries supports the revenue and other departments in the state for investigating post-event situations. Broad risk identification of ‘landslide potential areas’ and ‘sinking zones’ in Shimla city has been identified by the department.

In addition, Geological Survey of India and National Remote Sensing Centre are involved in mapping landslide hazard in the state (select hotspot monitoring).

Geological Survey of India (Chandigarh Office)

Geological Survey of India office at Chandigarh is responsible for coordinating and understanding geological studies for landslide hazard mitigation and for carrying out landslide hazard zonation, monitoring landslides and avalanches and studying the factors responsible for sliding and suggesting precautionary and preventive measures.

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

Integrated Disease Surveillance Project (IDSP) aims at improving the efficiency of disease surveillance for use in health planning, management and evaluating control strategies. It is intended to detect early warning signals of impending outbreaks and help initiate an effective response in a timely manner. Himachal Pradesh was the first state in the country to launch IDSP. In Himachal Pradesh, the programme is implemented under the National Rural Health Mission, Department of Health and Family Welfare, Government of Himachal Pradesh.

Diseases in the list of regular surveillance include:
• Vector-borne diseases: malaria (other vector-borne diseases under this group), dengue, JE, leishmaniasis, chikunguniya etc.
• Water-borne disease: acute diarrhoeal disease (cholera)
• Respiratory diseases: typhoid, tuberculosis
• Vaccine preventable diseases: measles
• Diseases under eradication: polio
• Other conditions: road traffic accidents (link to police computers)
• Other international commitments plague
• Unusual clinical syndromes: menigoencephalitis/ respiratory distress, hemorrhagic fevers and other undiagnosed conditions.

Diseases under sentinel surveillance include:
• Sexually transmitted diseases/blood-borne: HIV/ HBV, HCV
• Other conditions: water quality, outdoor air quality (large urban centres)

City specific diseases include:
• Scrub typhus
• Thyroid deficiency disorders
• Cancer
• Rheumatic heart disease
• Cutaneous leishmaniasis

The function of District Surveillance Unit is the collation and analysis of data received from all reporting units and transmitting to State Surveillance Unit (SSU) and SSU transmitting it to Central Surveillance Unit. In addition, DSU constitutes rapid response team (RRT), which is deputed to the field, wherever needed. to implements/monitors all project activities.

IDSP coordinates with public health laboratories, medical college, NGOs, private sectors, and sends regular feedback to the reporting units on analysis of data. DSU would organize training and meetings of DSC within the districts. The reporting units, medical colleges and the district hospital are part of the functioning levels for implementation of IDSP.

Outbreaks caused due to poor sanitation services or mixing of sewage with water supply are handled by the Health Department of SMC (Municipal Health Officer is the nodal officer for Shimla city). Indira Gandhi Medical College, Shimla, collaborates with Directorate Health services for the IDSP project. The samples collected by the State Surveillance Unit are sent for laboratory test at IGMC and other laboratories based on case basis. Investigation by the State RRT and the District RRT has been effective and outbreaks are identified/confirmed much before media publish the news.

IDSP Cell at Shimla has a strong collaboration with the media. Information on prevention and care during outbreak is announced through cable television, FM channels, All India Radio (prime time) and through distribution of vernacular IEC materials.

Central Water Commission (CWC), Directorate at Shimla

Central Water Commission (CWC) provides flood forecasting and warning. The flood forecasting network of the CWC covers all the major flood-prone inter-state river basins in the country. Flood forecasting and warning system are used for alerting of likely damage and enable people to move and also remove their moveable property to safer places.

In the state of Himachal Pradesh, the CWC has set up a Directorate at Shimla for monitoring of floods. CWC has established flood forecasting network in the Satluj basin at Titang, Powari, Nathpa, Rampur and Pandoh. CWC has also established two telemetry-based automatic gauge stations along the Parechu River. The Directorate at Shimla is also engaged in snow hydrological studies and, with the help of NRSC, Hyderabad, is forecasting snowmelt run off in Satluj, Yamuna, Beas and Chenab basins in the state. Daily gauge and discharge data are collected manually and, from two telemetric locations along Parechu River, are transmitted to Shimla station through VSAT arrangement. This information is further disseminated by email/fax during flood season.

Himachal Pradesh State Disaster Management Authority, Department of Revenue (Disaster Management Cell), Government of Himachal Pradesh

The Himachal Pradesh State Disaster Management Authority (HPSMDA) has streamlined plan preparation for disaster management at the state, district and at select cities across the state. HPSMDA have issued guidelines to all the departments for undertaking capacity building, training, preparation, department-specific disaster management plans etc. Guidelines for on-site and off-site emergency plans for factories have been issued. State-wide hazard vulnerability and risk assessment study have been commissioned.

The state policy on DM has also been issued. The authority is in the process of establishing the State level Emergency Operation Centre (to be located within HP Secretariat). This EOC will strengthen the existing control room and will be the nerve centre for coordination and management of disasters. For information flow, besides its own toll free number, 1070, the SEOC is also connected to the existing network of emergency 108, Police and Fire. The SEOC has direct connection with NEOC and early warning networks of all nodal agencies at the national and state levels. The SEOC acts as a centralized coordination unit to provide direction on receipt of early warning or on occurrence of event.

9.5 INDICATORS OF THE EXISTING CONDITION OF EWS

Table 8: **Criteria development matrix: Indicators of existing condition of EWS in Shimla**

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)	●	○	○	○	○	The State Disaster Management (DM) Plan has no mention of role/mandate for Shimla Municipal Corporation as a part of the EWS framework. This constrains the development of EWS at the city level. The legal status of EWS establishment at the city level is unclear
1.2	Institutional mechanism for local authority (ULB) is an integral part of EWS framework (document, mandate, implementation)	●	○	○	○	○	The Shimla City DM Plan has mention of EWS; however, it does not indicate any institutional mechanism and the role of Shimla Municipal Corporation (SMC) as part of the EWS framework
1.3	ULB accorded with the authority to disseminate warnings (mandate, SOP, implementation)	●	●	●	○	○	Dissemination of warnings is done by SMC Health Department to the city via local newspaper. No SOP is currently in place
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)	●	●	○	○	○	DM plans exist but are partially implemented. Preparedness actions are evident for earthquake hazard and public health risks

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. This is evident for landslide prone areas, snowfall and public health risks (areas with poor access to water and sanitation services). The hotspots are not clearly demarcated
2.2	Outreach practice (dissemination of warning)	●	●	●	○	○	Forecast exists for weather events, warning exists for all key hazards (excluding earthquake and landslide), and information is provided by IMD and health department to government institutions and media. There is lack of integration of existing warning systems with arrangements for service providers (transport, education, electricity, water supply etc.)
2.3	Timely dissemination of warnings to vulnerable groups (residing in slums, high risk prone areas)	●	●	○	○	○	Warning of disease outbreak is provided to slums through IDSP. No clear mechanism exists for warning of other hazards
2.4	Arrangement for night time warning (limited to floods, landslides, cyclones, tsunamis)	●	○	○	○	○	Arrangements for night time warning do not exist and the need is yet to be realized
2.5	Media engagement in dissemination of warning	●	●	●	○	○	Media engagement with the forecasting agencies is evident specifically at the Meteorological Centre, Shimla. Media engagement in prevention of health risks is evident through engagement with the state department health agencies
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)	●	○	○	○	○	No formal mechanism for dissemination of warning to citizens and tourists exists

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)	●	●	○	○	○	City level risk assessment has not been undertaken, qualitative ward level hazard indication is provided within the City DM Plan
3.2.1	Warning mechanism for geophysical hazards (earthquake)	●	○	○	○	○	The city of Shimla does not have geophysical early warning/alert system
3.2.2	Warning mechanism for hydro-meteorological hazards (cyclone, severe winds, heat wave, cold wave, extreme rainfall, fluvial flooding, pluvial flooding)	●	●	○	○	○	Warning related to snow and extreme rainfall is currently being provided by IMD with inadequate respite time. No warning mechanisms currently exist for heat wave, cold wave, pluvial flooding
3.2.3	Advisory mechanism for public health risks (vector-borne and water-borne diseases)	●	●	●	●	○	Demarcation of areas based on active and passive surveillance is currently done under IDSP. There was no evidence of involvement of private stakeholders. Advisories are provided upon the realization of disease outbreak
3.3.1	Availability of technology to nowcast/forecast geophysical hazards by technical agencies	●	○	○	○	○	The city is highly prone to earthquake and landslide, but there is currently no mechanism to monitor and arrive at thresholds for landslide events within the city limits. There is high dependency on national agencies for observing, monitoring and forecasting
3.3.2	Availability of technology in nowcast/forecast of hydro-meteorological hazards by technical agencies	●	●	●	○	○	Technology to forecast and nowcast is being implemented by IMD
3.3.3	Disease surveillance system (surveillance coverage, collection method, analysis)	●	●	●	○	○	Health surveillance at district level is being carried out by IDSP, and at city level is being carried out by Health Department, Shimla Municipal Corporation. Information is collected on paper-based forms. Technology to address city-specific needs is currently limited
3.4	Uncertainty in forecast and warning (hydro-met, public health)	●	○	○	○	○	For hydro-meteorological hazards forecast is provided by IMD to select government institutions and media. Warning based on forecast requires improvement. There exists no forecast or warning mechanism for geophysical hazards. For public health, the health department has no forecast mechanism, but provides warning upon realization of the outbreak

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	●	●	○	○	○	Budget head does not exist and currently, the expenses towards disaster preparedness/EWS are being made from miscellaneous heads. There is no evidence of realization of the need for having a separate budget for EWS
3.6	Data availability for operations of EWS	●	●	○	○	○	Council of Science and Technology has made attempts to collate data. ULB is currently not involved in the process
3.7	Staffing and capacity within local authority for operation and maintenance of EWS	●	●	●	○	○	Currently, the local authority provides only health advisories. Realization of need for dedicated staff for EWS is not evident
3.8	Use of modern technology to disseminate warning (hydro-met, public health)	●	●	○	○	○	There are two sirens which are currently operational. One is located at EOC and other at IMD. There is a plan for installation of digital displays. Modern technology are being used for providing hydro-met warning. Health advisories are generally provided to public at large through local newspapers and television. Use of modern technology for disseminating warning does not exist for geophysical hazards
3.9	Redundancy (multi-mode) in communication networks	●	●	○	○	○	Recognition of need is evident within technical institutions and state authorities only
3.10	City Emergency Operations Centre (EOC) for housing data of hazard, vulnerability and risk	●	●	○	○	○	The state EOC (SEOC) is located within the city. The SEOC is realized to function for the state and the city. Due to the presence of SEOC, there is no realization of need by the ULB or other technical institutions to establish a city EOC

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	●	●	●	○	○	City level macro details are included for hydro-meteorological hazards (limited to rainfall and snow)
4.2	Raisng awarenss about warnings at city level	●	●	○	○	○	Efforts are being made to raise public awareness on frequent hazards. Awareness programmes are currently conducted by HPSDMA/DM Cell (State), 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 need assessment has not been undertaken. But there is a realization for need for specific products by various departments, especially for the geophysical, hydro-met and public health risks
4.4	Risk communication	●	○	○	○	○	Risk assessment is not undertaken at the city level. 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 functional city EOC, the state–district–city level agencies communicate on need basis. A well-coordinated mechanism to stage actions on receiving warning is not evident
5.2	Extent of links between disaster management agencies and service providers	●	●	○	○	○	No formal links between agencies is evident. Select service providers are informed during the onset of an event
5.3	Extent of links between media and disaster management agencies	●	●	●	○	○	Reflection of warning information in media products is evident (information passed by IMD to local media). Links between media and technical agencies were found to be stronger with IMD through their frequency of interaction in comparison to the SMC

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 and service providers are aware of the extreme rainfall/snow warning (IMD vs. District Collectorate, Municipal Corporation Officials) and health risks (IDSP vs. Health Department of SMC), but few evidence of coordinated actions was evident
6.2	Extent to which the warning mechanism allows for feedback from the affected area	●	●	●	○	○	Limited feedback mechanism exists and it does not include all stakeholders. Communication of warning is more unidirectional – technical agencies to disaster management agencies (state/district/city). The authority to issue warning is with the state and the districts. For geophysical and hydro-meteorological hazards, there is no evidence of confirmation and feedback mechanism. In case of public health, it is achieved through field workers providing feedback on a weekly basis.
6.3	Level of reflection and learning evident within local authority	●	○	○	○	○	Post event reflection is done. There is no evidence of increased communication and response mechanism for geophysical and hydro-meteorological hazard risks. In case of public health, the reflection and learning takes place between State IDSP Cell and the Health Department of SMC
6.4	Monitoring, evaluation and targets for improvement of EWS	●	○	○	○	○	No formal procedure to monitor the EWS is in place

9.6 SUMMARY

Shimla city, being the capital of Himachal Pradesh, has distinct advantage of institutional presence and resources for management of severe event (disasters) and risk reduction activities. The city has the presence of institutions catering to the needs of services in disaster management. Key institutions include: HPSDMA/DM Cell Department of Revenue, Meteorological Centre (Shimla), Geology Wing of Industries Department, Aryabhatta Geoinformatics and Space Application Centre (AGiSAC), IDSP (State Surveillance Unit), and Municipal Corporation of Shimla (Urban Local Body). The city is also implementing a range of programmes on disaster risk reduction and climate risk management aspects.

The institutional framework for early warning system (severe weather warning) is limited to information received from the Meteorological Office (MO), Shimla, and the mechanism established by IDSP for disease outbreak. Given the city dynamics and limitations due to geographical location and spread, a well-established EWS for geophysical and hydro-meteorological hazards is the need of the hour. The City Disaster Management Cell of SMC rolled out the first City Disaster Management Plan in 2012 (under the GoI-UNDP Disaster Risk Reduction Programme). The document indicated the hazard profile of the city, vulnerability and risk posed to the city for various hazards, and outlines the mitigation and response plan for the city. The section of the plan also outlines the trigger mechanism for various hazards. However, discussions with key stakeholders in the city and the state department reveal that there is need for greater coordination and establishment of EWS in the city.

The overall vulnerability of Shimla to various hazards is high complex function of hazard intensity, population (densely-packed settlements, settlements in dangerous and environmentally fragile zones), exposure of assets, remoteness/accessibility, socio–economic factors, services and utilities outreach and infrastructure vulnerability (critical buildings, transport – roads and railways, communications). The city of Shimla now has a larger and more densely-packed population, coupled with terrain challenges the exposure to risk of damage caused by hazard events stands to be significant. Well-established EWS to potential hazard risks will ameliorate disaster risk management concerns of the city.

The review of key agencies brought to the forefront, the need for early warning system for all hazards. Success of any EWS will depend on the detailed understanding of city risks. In case of Shimla, qualitative risk assessment has been undertaken and key locations and hotspots are known to SMC and stakeholders. This information is, however, rudimentary and cannot be used for potential impact assessment or warning to vulnerable population in the city. Post-Uttarakhand Tragedy (June 2013) there has been a growing concern for developing early warning system and addressing the forecast needs and dissemination mechanism to the stakeholders.

At present, the only evidence of forecast is developed for weather events by the Meteorological Office (MO) in Shimla. This forecast also needs significant improvement so as to identify and track extreme events within the geographical area of the city. Lack of field studies and updating of vulnerability assessment limits the dissemination to intended users. The target for warning is purely based on past experiences and from observed phenomenon in some cases (sinking zones, building tilts, mass wasting and debris flow). Translation of severe weather warning to potential impact is not analysed at the moment. City and state level agencies realize the need for precise local weather forecast and plan for establishment of monitoring mechanism for geophysical hazards in the city.

Health advisories and warning are currently provided by health department and IDSP upon realization of disease breakout. Technology used to monitor, nowcast and disseminate hydro-meteorological event warning and geophysical event alerts is currently limited and lacks required data/information to address city specific needs.

The current method of dissemination of extreme weather warning to all nodal agencies is through mail/fax and SMS being sent from MO, Shimla, to government departments. The information is also disseminated to general public through local media (print, radio and television. General public are unable to translate the forecast into warning or actionable points. Addressing the last mile connectivity is still an issue.

SMC has been supported by UNDP for preparation of the City DM Plan and there has been significant effort to capture the operational components for disaster management and risk reduction in the CDMP. The City EOC is located in the city. Though these developments are very recent, there is a need to further strengthen the mechanisms within the City EOC and develop a SOP for functioning of the EOC with appropriate number of trained staff on a 24X7 basis. In the absence of the functional State EOC, the strengthening of City EOC is imperative.

Due to terrain constraints and the threats of hazard, the EOC has to be established at both the state and the city levels. In the non-emergency period, the city EOC can be advised to collate data and monitor specific hazard risks such as slope instability, sinking zones and ground failure due to wrong construction practices and update the risk profile of the city. This database shall strengthen the EWS mechanism and help to establish threshold levels for hotspots and risk zones and determine potential impact for key hazards.

Evidence of warning mechanism exists only for severe weather events and for health risks. Information from the technical agencies is passed on to the disaster management agencies/response agencies and based on the past understanding of the events, response is initiated. The staging of response may differ due to lesser understanding of the severity/intensity of the event or due to no real time information management system from the impact zones/areas. Two of the agencies (MO Shimla and IDSP) currently providing these warnings realize the need for development of their products and services.

The lack of user needs assessment across all stakeholders could be the reason for isolated technology incorporation, product development, service delivery plans and integrated with the CDMP. Both MO Shimla and IDSP undertake awareness programmes on their respective subjects and, in addition, a wide range of departments in the state also conduct public awareness campaigns on life safety and preparedness (including drills) for earthquakes, landslides, cloud bursts/flash floods and fire.

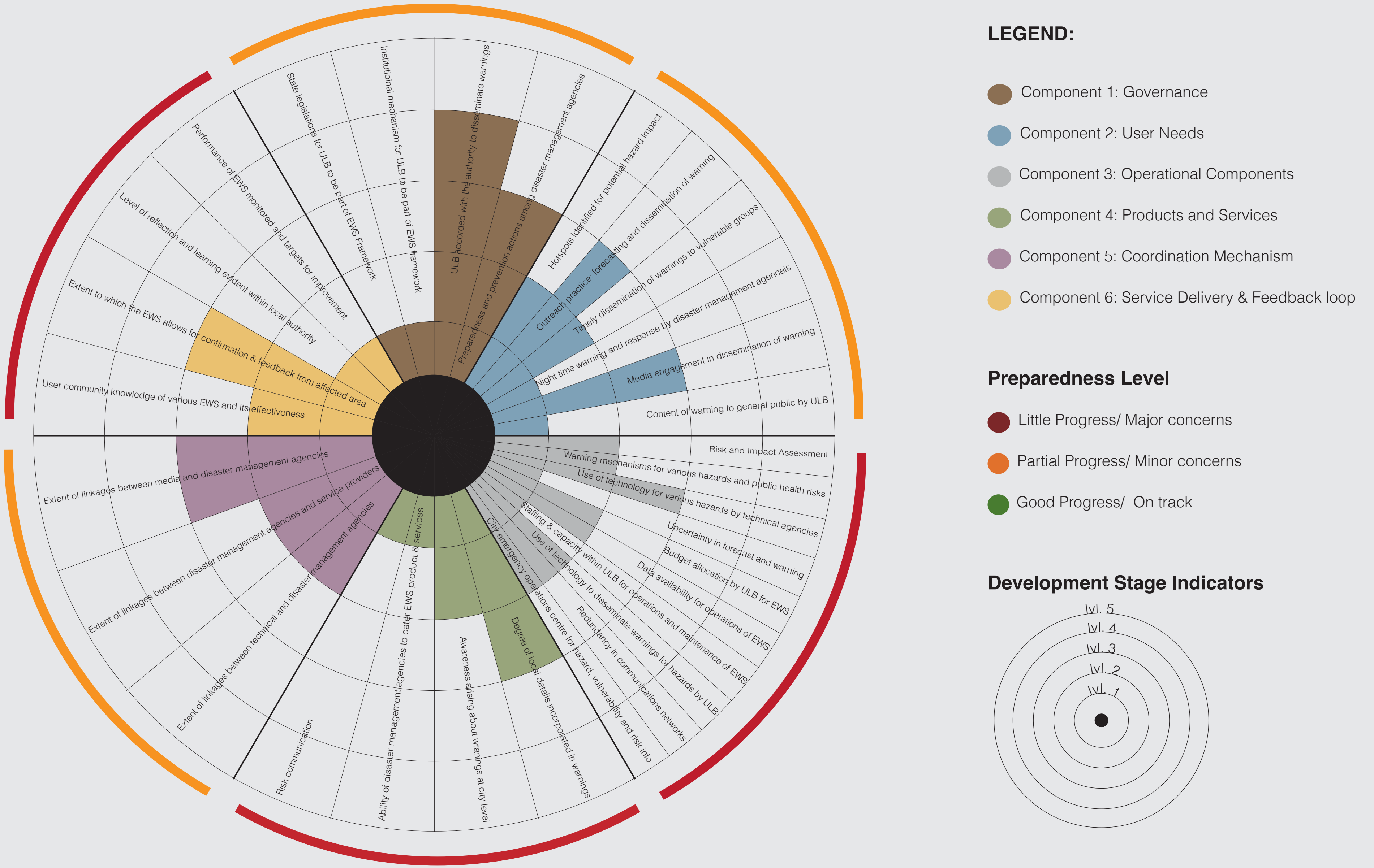


Figure 20: **Preparedness of EWS indicators for Shimla**

THIRUVANANTHAPURAM

Notes:

City	Thiruvananthapuram
District	Thiruvananthapuram
Area	141.74 Sq. Km.
Height from Sea Level	10 Mtrs.
Population	0.75 Million (as per 2011 census)
No. of Wards	100

Key Hazard:
Tsunami, Earthquake, Landslide
Pluvial Floods, Fluvial Floods, Cyclone,
Lightning, Kaddakadal (Surge)
Dengue, Malaria, Chikangunia

Sources:
Census of India, 2011
Thiruvananthapuram Corporation, 2014
GeoEye Imagery; Google Earth Pro 2014.

Figure21: **Satellite Image and basic information: Thiruvananthapuram**

10. REVIEW OF EWS IN THIRUVANANTHAPURAM

10.1 GENERAL CITY INFORMATION

Trivandrum or Thiruvananthapuram, is situated on the west cost of India within the Thiruvananthapuram district and is the capital of the state of Kerala. This district can be divided into three geographical regions, viz., highlands, midlands and lowlands. Natural growth and urban development is evident within the midland and lowland regions, while the highlands consists of plantation crops and reserved forests with scattered settlements.

Thiruvananthapuram is a city of hills and valleys; the ground elevation varies between 0 and 76 m above the mean sea level. The city region consists of a number of rivers and canals, both natural and manmade. The important rivers flowing through the city are Karamana, Killi, Vellayani and Thiruvallom. Akulam backwaters also lies within the city. Karamana and Killi Rivers run from north-east to south-west skirting the city and before meeting the sea to form islands, mainly Edayar Island, and water lagoons. In addition to these rivers, the city has five canals, namely, Ulloorthodu, Pattomthodu, Vanchiyoorthodu, Thekkinakarathodu and TS canal. These five canals flow through the valleys and they also drain off the surface water of the city.

There are many natural ponds within the city. Surface run off from the nearby area flows into these ponds. The major storm water drainage collection basins in the city region are Veli and Aakulam lakes in the north as well as Edayar and Vellayani lakes in the south. The TS Canal, also called Parvathy Puthanar, runs along the north-south direction connecting the Edayar and Aakulam lakes and continues to flow towards the north.

Thiruvananthapuram experiences humid tropical wet climate. The climate is humid in the coastal areas and is slightly cooler and drier in the interior region. The mean maximum temperature is 34 °C and the mean minimum temperature is 21 °C. The city benefits from two monsoons, viz., south west monsoon and north east monsoon. The region experiences somewhere around 120–140 rainy days per year.

The Thiruvananthapuram municipality came into existence in 1920. The municipality was converted into corporation on 30 October 1940. The area of city was increased from 86 wards to 100 wards in October 2010 by adding a few village panchayats into the corporation. As per census 2011 total population of city is 9,57,730 and density is 4454/sq km.

10.2 BACKGROUND ON HAZARD RISK

Geophysical Hazard

The Kerala region, which lies in peninsular India, is generally defined as a Stable Continental Region (SCR), in the context of seismic activity. However, the state of Kerala and its vicinity have had occasional mild tremors since historical times (Rajendran et al. 2009 & Seth, A. et al. 2006). Geologically, the city is characterized by sandy soil along the west coast and red laterite soil in the eastern regions. Granite deposits exist in some parts of the city, especially at Peroorkada and Thirumala.

Kerala experienced seismic activity in the recent past in clusters along with the border of Tamil Nadu, mainly in the districts of Idukki and Pallakad. A number of faults have been identified in Kerala out of which a few like the Periyar fault are active. The seismic hazard map of India was updated in 2000 by the Bureau of Indian Standards (BIS). There are no major changes in the map with respect to Kerala. All districts in the state lie in zone III. The maximum intensity expected in these areas would be around MSK VII. It must be noted that BIS estimates the hazard, based in part, on previous known earthquakes. The whole of Thiruvananthapuram District falls under Moderate Risk Zone where a maximum intensity of VII can be expected. According to GSHAP data, the state of Kerala falls in a region of low to moderate seismic hazard. As per the 2002 Bureau of Indian Standards (BIS) map, Kerala also falls in zones II and III while Lakshadweep lies in zone III. Historically, parts of this state have experienced seismic activity in the M5.0 range.

The coast of Kerala is relatively flat and practically at sea level. Parts of Thiruvananthapuram city were also affected by the tsunami event, which occurred on 26 December 2004, triggered by the earthquake in Sumatra region. At 6:58 a.m. (IST) on 26 December 2004, a massive earthquake of magnitude 9.1 hit Indonesia off the west coast of Northern Sumatra. Thirty-two villages were affected by the tsunami waves, of which 14 villages were in Thiruvananthapuram Taluk, 11 in Chirayankeezhu Taluk and 7 in Neyyatinkara Taluk. Three southern districts of Ernakulam, Allapuzha and Kollam were heavily affected due to the diffraction of the waves around Sri Lanka (Seth, A. et al., 2006). The southernmost district of Thiruvananthpuram, however, did not experience damage. This was possibly due to the wide turn of the diffracted waves at the peninsular tip.

The city has undulating topography with ground level rising from the MSL up to 75 m. However, the city is not likely to be affected by incidences of landslide or mud flow/debris flow.

Hydro-Meteorological Hazard

Thiruvananthapuram city receives a very high average annual rainfall of over 1800 mm. Continuous occurrence of high intensity rainfall for a few days is the primary factor contributing to floods within the city. Thiruvananthapuram is prone to gale-force winds, storm surges and torrential downpours accompanying dangerous cyclones originating from the Indian Ocean.

Two major rivers, viz., Karamana and Killiar, along with some small streams flow through the city area. The city also has a large network of storm water canals and drains. However, most of the storm water drains and canals in the city carry semi-treated and untreated sewage and have been depositories for solid waste. Recurrent floods caused by improper drainage system are one of the major perpetual problems faced by Thiruvananthapuram city.

Due to the city's close proximity to the coast, Thiruvananthapuram experiences kallakkadal – a term used to describe freak flooding in the parlance of fishermen. Kallakkadal is known to occur along the southern coast of India, mainly during the pre-monsoon period, in April and May, marked by clear weather. Flooding turns severe on the days of spring tide. Though not well-documented in scientific literature, the swells occur almost every year with varying intensity. They are characterized by long period waves, with frequency of more than 15 seconds.

Public Health Risks

Kerala is frequently affected by water- and vector-borne diseases, such as dengue, chikungunya, malaria and leptospirosis. The geographical and ecological factors of the state are such that the eastern high ranges have high humidity and rainfall, which in turn support the breeding of mosquitoes. Recent outbreaks were in 2006 (chikungunya) and 2007 (malaria). The coastal belt was hit in 2006 and the high ranges in 2007. Thiruvananthapuram was one of the grossly affected districts in the epidemic of 2007.

Thiruvananthapuram has geography and climate which are favourable for the breeding of aedesalbopictus, the suspected vector. Rubber plantations with latex containers, cocoa plantations and pineapple plantations in the highland add to the burden. Climate change may pose new challenges for the control of infectious diseases and public health.

10.3 BRIEF VULNERABILITY PROFILE

Thiruvananthapuram is exposed to a multitude of hazards and is categorized as a multi-hazard prone city due to its location. The city experiences various kinds of disasters of recurrent nature, which result in loss of life, livelihood and property (public and private), and disruption of economic activity, besides causing immense misery and hardship to the affected population.

The physical vulnerability of the city is high due its growth pattern. The city is expanding along the major transportation corridors, with concentration of urban development in a few major nodal points. Arabian Sea to the west is a physical barrier for growth of the city. Thiruvananthapuram city experienced urban floods problem due to blocked or inadequate storm sewers and increased urbanization. Further, wrong land-use practices and mismanagement of water resources in and around the city have increased the vulnerability of the city's population. Human interventions contributing to flood problems include reclamation of wetlands and water bodies, change in land-use pattern and construction of dense networks of roads. Increased floodplain occupancy has also increased the flood impacts in the city.

10.4 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.

Indian Meteorological Department (IMD)

Meteorological Centre, Thiruvananthapuram, caters to the requirements of Kerala state and Lakshadweep Islands by supervising and coordinating the weather services in the state. Weather forecast (both aviation and non-aviation) for optimum operation of weather sensitive activities like agriculture, irrigation, aviation etc. and warnings against severe weather phenomena (over the state and nearby sea area) like heavy rains, thunderstorm, strong winds etc., which cause destruction to life and property are rendered by this centre under the technical advice of Area Cyclone Warning Centre of Regional Meteorological Centre (ACWC) at Chennai.

ACWC issues four stage warnings on cyclone alert and cyclone warning, in case a weather system is detected near the coast. After receipt of pre-cyclone watch bulletin issued by HQ, ACWC/CWC monitor issues of warnings under two stages warning system – cyclone alert and cyclone warning. Cyclone alert is issued 48 hours in advance of the commencement of adverse weather to the Collector of coastal districts and the Chief Secretary of the concerned maritime state. After alert message is issued for broadcast, the concerned AIRs are requested to maintain round-the-clock watch to receive and broadcast the subsequent numbered bulletins. Cyclone warning is issued 24 hours before the commencement of adverse weather. Subsequent to this warning, any other crucial warning is sent more frequently to all the concerned recipients (Collectors and Chief Secretaries), if the storm is tracked by radar with a high degree of confidence. These recipients will be informed that subsequent warning on the storm will be broadcast by the AIR stations. The final stage of the warning, i.e., Post Landfall Outlook (PLO) meant for interior districts is issued 12 hours before the estimated landfall of the storm for the notice of the Collectors.

Dissemination of warnings, other than AIR, is through satellite-based Cyclone Warning Dissemination System (CWDS) installed at maritime district HQ, so that district authorities can initiate appropriate precautionary measures on receipt of such warnings. This scheme makes use of the S-band broadcast capability of INSAT satellite. At present there are five CWDS stations located in Kerala, which are at Thiruvananthapuram, Alappuzha, Ernakulam, Thrissur and Kozhikode.

Heavy rainfall warnings are issued to District Collectors when rainfall amount is expected to exceed by 7 cm per hour. The warning is also issued to various agencies, such as public services, PWD, irrigation, hydro-electric, port, telegraphs, railway and community project officials, so that the disaster management machinery can be kept in readiness.

Continuous monitoring of earthquake is done by state-of-art instruments installed at Thiruvananthapuram centre of IMD. Continuous monitoring of surface ozone, measurement of solar and terrestrial radiation and recording of atmospheric electricity are some routine activities of this office. Climatology section undertakes the scrutiny and archival of meteorological data and use such data over a number of years for answering various weather-related enquiries from different users for research and planning purposes.

When wind speed over sea area is expected to exceed 45 kmph up to 75 Nautical miles from the coast, wind warnings are issued and communicated to the Director of Fisheries, all Deputy Directors of Fisheries and Director of Ports through fax/ SMS through VPN connection, advising fisherman to be cautious while venturing into the sea. Meteorological Centre, Thiruvananthapuram, also provides weather information at toll free number 18001801717.

Indian National Centre for Ocean Information Services (INCOIS)

The Indian National Centre for Ocean Information Services (INCOIS) has a mission to provide the best possible ocean information and advisory services to the society, industry, government and scientific community through sustained ocean observations and constant improvement through systematic and focused research.

The Indian Tsunami Early Warning System established at INCOIS has the responsibility of providing tsunami advisories to Indian mainland and the island regions. The Warning Centre is capable of issuing tsunami bulletins in less than 10 min after any major earthquake in the Indian Ocean, thus leaving us with a response/lead time of about 10 to 20 minutes for near source regions and a few hours in the case of mainland. Currently, the warning centre disseminates tsunami bulletins to various stakeholders through multiple dissemination modes simultaneously (fax, phone, emails, GTS, SMS etc.).

Geological Survey of India (Thiruvananthapuram Office)

Geological Survey of India office at Thiruvananthapuram is responsible for conducting/ coordinating geological studies for landslide hazard mitigation. They are also the key agency for preparing and updating landslide hazard zonation, monitoring and suggesting precautionary and preventive measures. However, there currently is no forecast or warning mechanism for landslides.

Centre for Earth Science Studies (CESS)

Centre for Earth Science Studies (CESS) is a premier institute established to conduct researches and studies related to the Earth System. CESS along with INCOIS has recently installed (2011) two tsunami buoys and two stations scheduled off coastal waters of Kerala at 30 m depth off Thiruvananthapuram.

The coastal station provides real time data on coastal weather conditions, which includes tide, current and wave parameters. This information is vital to the local community, especially the fishermen during extreme weather conditions for safe planning of their activities and also in identification of potential fishing zones. The real time data will also be disseminated to the various scientific institutions to carry out research on coastal hydrodynamics and applications of sea-state forecasting.

The wave rider buoy data is currently extensively used for the calibration of observations made by the satellite sensors and for various applications in fisheries, coastal zone management, oil exploration, offshore/coastal engineering works and for field of calibration and validation of sea-state forecasting model .

CESS issues voice messages daily (mobile collaboration with Reliance network for the registered users) in the local languages through radio.

Kerala State Disaster Management Authority (KSDMA)
Kerala State Disaster Management Authority (KSDMA) was established as an apex decision-making body to facilitate, co-ordinate, review and monitor all disaster-related activities in the state, including capacity building. The KSDMA is responsible for the preparation and implementation of State Disaster Management policy, guidelines, State Disaster Management Plan and departmental plans. The authority is provided with statutory powers to facilitate, coordinate and monitor the activities related to disaster management utilizing the resources and expertise of relevant government departments, district administration, local authorities, non-governmental organizations, the public sector, international development agencies, donors and the community.

Kerala State Disaster Management Rule was passed in March 2007, Kerala State DM Authority was formed in May 2007, District DMA in September 2009, KSDM Policy was released in 2009 and DM plan in 2011.

Institute Land and Disaster Management (ILDM)
Institute of Land and Disaster Management (ILDM) is an autonomous body constituted under the Revenue Department, Government of Kerala, to impart professional training, including induction training, in-service training and refresher training to personnel of the Land Revenue and Survey Department of Kerala State.

HVRA Cell (KSDMA)
Hazard Vulnerability and Risk Assessment (HVRA) Cell, the research and technical unit of the State Disaster Management Authority.

IDSP and Health Department
Under IDSP, data is collected on a weekly (Monday–Sunday) basis. The information is collected on three specified reporting formats, namely ‘S’ (suspected cases), ‘P’ (presumptive cases) and ‘L’ (laboratory confirmed cases) filled by health workers, clinicians and clinical laboratory staff respectively. State health department and district IDSP cell provide health advisories using IEC material.

The Municipal Corporation’s Health Department is headed by Corporation Health Officer (CHO). The Health Department is responsible for conservancy services, sanitation facilities, solid waste management and other public health duties. The CHO is assisted by an Assistant Health Officer, 19 Health Inspectors and 45 Junior Health Inspectors (JHI).

Coordination meetings are held in March–April. Information is disseminated through local newspaper, radio, television and pamphlets. Information on heat wave, vector-borne and water-borne diseases are disseminated (advisory, dos and don’ts). Disease seasonality mapping is done every year through ward level health centres.

Port Authority
Thiruvananthapuram port office disseminates warning to medium- and small-sized vessels in the sea. They receive warning messages from IMD, especially on tsunami, cyclone and heavy wind.

Thiruvananthapuram Corporation
The Mayor, who is the elected member, is responsible for overall functions of TMC. Every year, before monsoon, meetings with all the departments are held to review the situation and take up activities to reduce risk of flooding and health-related issues.

Fisheries Department
There are 23,000 vessels and 2.5 lakh active fishermen in Kerala. Marine enforcement wing of the Fisheries Department enforces KMRF act of 1980 (The Kerala Marine Fishing Regulation Act). Fishing in the sea is banned from 15 June to 31 August (47 days). Fisheries Department receives weather-related information from the Irrigation Department, INCOIS, AIS (Automatic Identification System) transponder from 600 deep sea vessels. About 700 radio beacons are in place. Warning received by the Fisheries Department is disseminated through PAS, SMS and radio.

Department of Environment and Climate Change
The Department of Environment and Climate Change is the EIA authority and is mainly responsible for issuing environmental clearances. Climate change activities are currently restricted to preparation on state action plan on climate change.

Implementation of SAPCC in a phased manner will be taken up by the same department.

Irrigation Department

Irrigation Department has carried out flood mitigation studies for Killi and Karamana rivers of Thiruvananthapuram city. They have also carried out studies for pollution abatement.

Geology Department and GSI

Geology Department is mainly responsible for mining-related activities and does not have much role to play in disaster-related matters. GSI, which is a national agency, is actively involved in mapping landslide prone areas, road corridor mapping, geotechnical changes and stability analysis in general. These studies are not city-specific.

10.5 INDICATORS OF THE EXISTING CONDITION OF EWS

Table 9: **Criteria development matrix: Indicators of existing condition of EWS in Thiruvananthapuram**

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)	●	●	○	○	○	State DM Policy has a section on early warning. Department of DM is responsible to give advance warning and alerts for cyclones, floods, tsunami etc. KSDMA ensures mechanism aligned with overall disaster management plan of the state to receive early warning and forecasting from nodal agencies such as IMD, CESS, INCOIS, etc., and to disseminate the warning information to vulnerable communities in the last mile
1.2	Institutional mechanism for local authority (ULB) is an integral part of EWS framework (document, mandate, implementation)	●	○	○	○	○	Preparedness actions are evident for tsunami and landslide at CESS, GSI and public health risks at District ISDP Cell. Tsunami buoys are installed in Arabian Sea by INCOIS. CESS also actively monitors the ocean stage situation. Irrigation Department is working on modelling Killi and Karmana rivers. Integration is not evident
1.3	ULB accorded with the authority to disseminate warnings (mandate, SOP, implementation)	●	●	○	○	○	Thiruvananthapuram City DM Plan has no mention of EWS. Clear mandate does not exist, but informal dissemination happens. Disaster management does not come under the purview of Municipal Corporation, but being the people's institution, Municipal Corporation needs to recognize the importance of disaster management and the need to mainstream it
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)	●	●	○	○	○	Dissemination of warning happens only for cyclone, heavy rains, high tide via DC Office. The information is provided by the local Met Centre, IMD through phone. Such warning mechanism is not evident at the Municipal Corporation level

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, further supported by limited field checks for heavy rainfall and urban floods
2.2	Outreach practice (dissemination of warning)	●	●	●	○	○	Extreme weather forecast (heavy rain, rough sea) is provided by IMD to the District Collector. The District Collector is responsible for disseminating the warning in district. Media also gather information from IMD/DC office/ULB
2.3	Timely dissemination of warnings to vulnerable groups (residing in slums, high risk prone areas)	●	●	●	○	○	Dissemination of warning exists for all hazards, but with limited response time. City does not get direct warning from Met agency/technical agencies
2.4	Arrangement for night time warning (limited to floods, landslides, cyclones, tsunamis)	●	●	○	○	○	No specific arrangement was evident within the city for night time warning
2.5	Media engagement in dissemination of warning	●	●	○	○	○	Local print/electronic media collect information from IMD, DC office, ULB, and Health Department/IDSP on a regular basis
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)	●	●	○	○	○	Work towards this is evident in the health department

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)	●	●	○	○	○	City level risk is not assessed, qualitative ward level hazard indication is provided within the City DM Plan in tabular form
3.2.1	Warning mechanism for geophysical hazards (earthquake)	●	●	●	●	○	Realization of need for warning by TVM Corporation. CESS works closely with INCOIS and has deployed tsunami buoys. INCOIS provides early warning related to tsunami to the State Disaster Management Department. No warning exists for earthquake and landslide hazards
3.2.2	Warning mechanism for hydro-meteorological hazards (cyclone, severe winds, heat wave, cold wave, extreme rainfall, fluvial flooding, pluvial flooding)	●	●	●	○	○	IMD Met Centre at Thiruvananthapuram is well-equipped. Forecast and warning information is provided to District Collector via SMS, fax
3.2.3	Advisory mechanism for public health risks (vector-borne and water-borne diseases)	●	●	●	●	○	District health office and IDSP Cell currently issue health advisories to the city
3.3.1	Availability of technology to nowcast/forecast geophysical hazards by technical agencies	●	●	●	○	○	GSI is monitors landslide situation on request. CESS is equipped for tsunami/ocean monitoring
3.3.2	Availability of technology in nowcast/forecast of hydro-meteorological hazards by technical agencies	●	●	●	○	○	IMD Met Centre at Thiruvananthapuram is well-equipped with state-of-art instruments and is able to provide forecast and warning to DM agencies in the state. It is also well-connected with the Regional Centre at Chennai, where DWR is installed
3.3.3	Disease surveillance system (surveillance coverage, collection method, analysis)	●	●	●	○	○	Monitoring of health situation at city level is being carried out by the District Health Office as well as the District IDSP Cell
3.4	Uncertainty in forecast and warning (hydro-met, public health)	●	●	●	○	○	Forecast does not exist for geophysical hazards. Forecast exists for hydro-met and public health risks with high uncertainty and no warning

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	●	○	○	○	○	Budget head does not exist in ULB for EWS
3.6	Data availability for operations of EWS	●	○	○	○	○	TVM corporation is currently not involved in the process of collection or collation of data for operation of EWS. Data available with different agencies in multiple formats, mainly qualitative information, not collated or aggregated. TVM Corporation has not mapped information on low lying areas/flood prone settlements. However, institutional memory of hotspots exists based on historical events, further supported by limited field checks for heavy rainfall and pluvial flood-related hazards
3.7	Staffing and capacity within local authority for operation and maintenance of EWS	●	○	○	○	○	Overseen by staff deputed on need basis, but not specifically trained for operating EWS
3.8	Use of modern technology to disseminate warning (hydro-met, public health)	●	●	○	○	○	For tsunami, INCOIS informs State DM Dept. Use of generic media such as newspapers, local cable channel and radio was observed. In addition to generic media, PAS is in place, but is limited to siren. Health advisories are generally provided to public at large through local newspapers and television
3.9	Redundancy (multi-mode) in communication networks	●	●	○	○	○	Telephone and fax are media used to receive warning in ULB. However, recognition of the need was expressed by technical institutions and state departments
3.10	City Emergency Operations Centre (EOC) for housing data of hazard, vulnerability and risk	●	○	○	○	○	EOC does not exist in TVM Corporation. However, HVRA Cell at ILDM is working towards establishment of State EOC in TVM

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	●	●	○	○	○	None, generalized warnings from technical agencies, need recognized, system under development. However, in public health advisories local aspects are identified
4.2	Raisng awarenss about warnings at city level	●	○	○	○	○	Awareness on health issues is created through advisories using local language pamphlet, literature, cable TV and radio
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 not undertaken. Products are generated for select health risks
4.4	Risk communication	●	●	○	○	○	Risk is not assessed at the ULB/ward level. The information communicated by technical agency is mainly on hazard information. This is shared with the government agencies and media

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	●	●	●	○	○	Links exist. Communication exists between agencies; however, there is need for enhanced coordination mechanism. Technical agencies have expressed willingness to coordinate with the ULB to upgrade the hydro-met network. Formalization of this link needs to be established
5.2	Extent of links between disaster management agencies and service providers	●	●	○	○	○	Informal link is evident in some line departments which need to be formalized
5.3	Extent of links between media and disaster management agencies	●	●	○	○	○	Media predominantly depend on information hosted on public domain

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	●	●	●	○	○	Corporation and service providers are aware of the warning, but less evidence (only IDSP vs. Health Department) of coordinated actions was evident
6.2	Extent to which the warning mechanism allows for feedback from the affected area	●	○	○	○	○	Feedback mechanism is not established with technical agencies and other departments at regional or national levels
6.3	Level of reflection and learning evident within local authority	●	○	○	○	○	Post-event reflections are only evident in case of public health risk. Learning documentation is missing
6.4	Monitoring, evaluation and targets for improvement of EWS	●	○	○	○	○	Performance monitoring mechanism needs to be established

10.6 SUMMARY

Thiruvananthapuram, capital city of Kerala state, has well-established links with national level early warning agencies and state level disaster management institutions. Thiruvananthapuram city has a good presence of key national level institutions such as Geological Survey of India (GSI), Indian Meteorological Department (IMD), and Centre for Earth Science Studies (CESS). It also has state level institutions such as KSDMA, ILDM and state IDSP cell. Thiruvananthapuram City Corporation has put in place a City Disaster Management Plan (CDMP). The local government and HRVA Cell (KSDMA) are working towards preparation of hazard, vulnerability and risk assessment.

As per the KSDMA, the need is recognized by the State Government to facilitate community participation in the improvement process of Early Warning System and Disaster Risk Management. Within the state, 295 selected vulnerable villages in all districts have been connected through EWS network; however, there is no involvement of ULB in the current efforts.

Early warning of impending disasters and their effective dissemination by using various alternative communications are the key factors for effective prevention and preparedness. Thiruvananthapuram city lies in the Thiruvananthapuram district and early warning on an impending event is the key responsibility of the District Collector. The District Collector (as ex-officio) is the Chairman of District

Disaster Management Authority (DDMA).

Meteorological Centre (IMD) at Thiruvananthapuram provides early warning information on heavy rains, thunderstorm and strong winds to the District Collector of Thiruvananthapuram. The District collector sends these early warning messages to various institutions, including the Thiruvananthapuram Corporation via fax, email and phone calls. Thiruvananthapuram Corporation informs the people within its jurisdiction on receipt of warning from the District Collector's office.

Thiruvananthapuram Corporation has very limited coordination mechanism with state and national agencies providing forecast and warning services. Thiruvananthapuram City Corporation realizes the need of an Emergency Operation Centre (EOC) and to establish link with INCOIS, CESS and IMD to receive warning message.

Centre for Earth Science Studies, in collaboration with Indian National Centre for Ocean Information Services (INCOIS) under the Ministry of Earth Sciences (MoES), Government of India, has installed (in 2011) two coastal stations, off the coastal waters of Thiruvananthapuram, at 30 m depth. The coastal station gives real time data on coastal weather conditions, which include tide, current and wave parameters. This information is vital to the local community, especially the fishermen during extreme weather conditions for safe planning of their activities and also in identification of potential fishing zones. The real time data is disseminated to the various scientific communities/research organizations/institutes to carry out research on coastal hydrodynamics and applications of sea-state forecasting.

The wave-rider buoy data is currently extensively used for the calibration of observations made by the satellite sensors and for various applications in fisheries, coastal zone management, oil exploration, off-shore/coastal engineering works and for field of calibration and validation of sea-state forecasting model. CESS also issues voice messages (mobile collaboration with a service provider network for the registered users) in the local languages through radio once at 8:30 a.m. and then at 6:15 p.m.

Health advisories are currently provided by Health Department and IDSP, upon the realization of disease break out. Health department issues health advisories especially before monsoon, as and when the situation warrants.

Early warning mechanism exists only for severe weather events and for health risks in Thiruvananthapuram City. Information from technical agencies are passed on to the disaster management agencies/response agencies and. based on the past understanding of the events/experiences, response is initiated.

When rainfall amount is expected to exceed by 7 cm per hour, heavy rainfall warning is issued by IMD to the District Collector. The warning is also issued to various agencies, such as public services, PWD, irrigation, hydro-electric, port, telegraphs, railway and Community Project Officials, so that the disaster management machinery can be kept in readiness. The existing system of dissemination of weather warning by IMD to nodal agencies is done through fax, email and SMS. The information is also shared to media and disseminated to the general public through local media (print, radio and television). Local media translate the forecast and warning into local language.

Coordination mechanism is well-established between agencies which are mandated to coordinate the response effort. District Collector's Office is the coordinating agency for early warning and disaster management. There exists no formal feedback mechanism between technical agencies and ULB, and between ULB and communities at risk. Establishing the feedback mechanism can ensure reflection and learning process, thereby improving the efficiency of the current system.

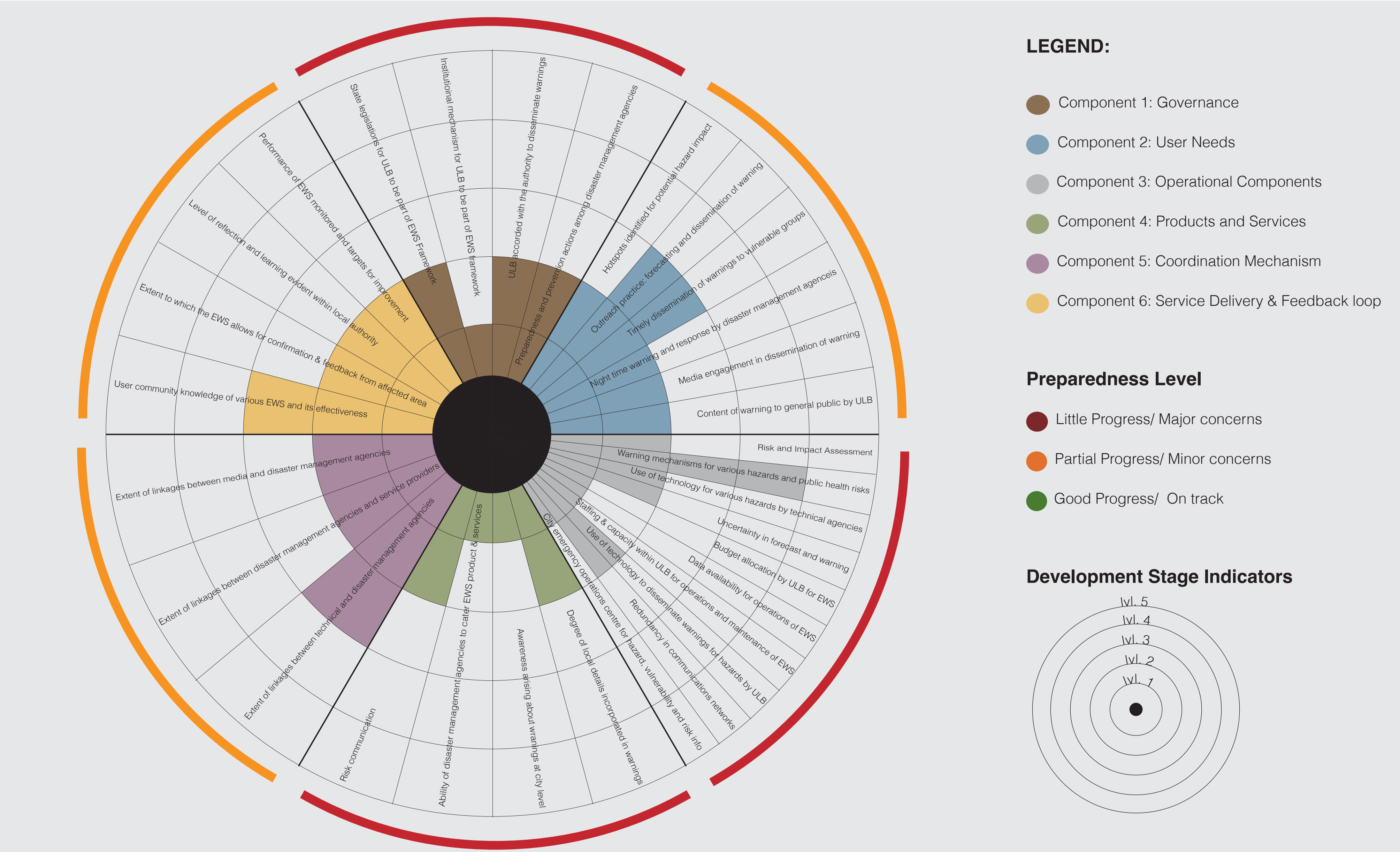


Figure 22**: Preparedness of EWS indicators for Thiruvananthapuram**

VISAKHAPATNAM

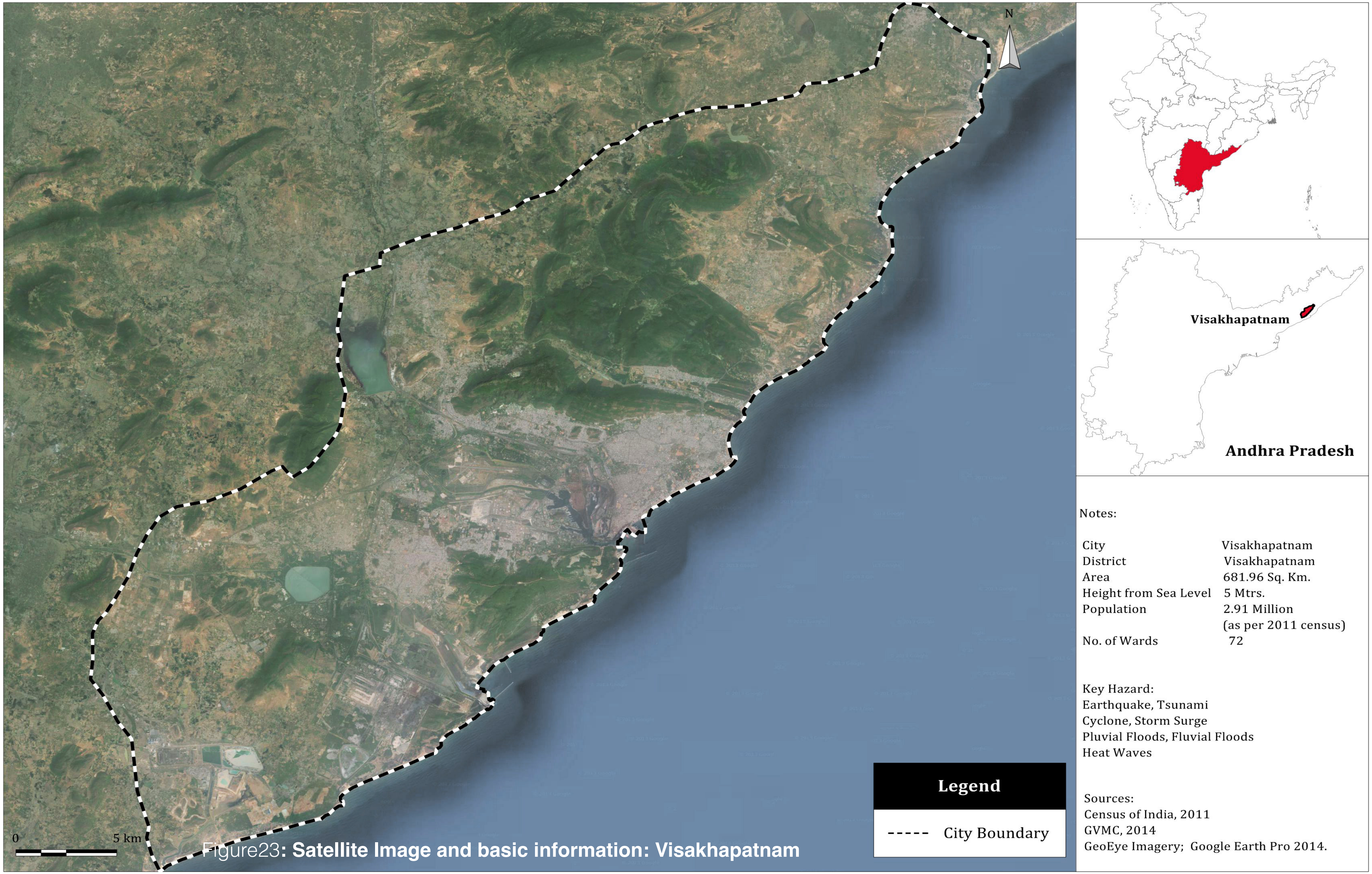


Figure23: **Satellite Image and basic information: Visakhapatnam**

11. REVIEW OF EWS IN VISAKHAPATNAM

11.1 GENERAL CITY INFORMATION

Visakhapatnam, popularly known as Vizag, is the administrative headquarters of Visakhapatnam district and headquarters of the Eastern Naval Command of the Indian Navy. It is nestled among the hills of the Eastern Ghats and faces the Bay of Bengal on the east.

As this review was underway, the decision to bifurcate Andhra Pradesh into Telangana and Seemandra was announced. The results of this review will have to be viewed from the lens of this development. While much of the early warning systems within the city and within national institutions will undergo limited change, the possibility state-level institutions, resources and coordination/communication mechanisms may undergo changes in the coming months.

Visakhapatnam is the third largest city on the east coast of India (after Chennai and Kolkata). The city is home to several state-owned heavy industries and a steel plant; it is one of India's largest seaports and has the country's oldest shipyard. Visakhapatnam has the only natural harbour on the east coast of India. The GVMC (officially, Greater Visakhapatnam Municipal Corporation), formerly known as the Visakhapatnam Municipal Corporation, is the civic body that governs the city of Visakhapatnam, India.

The city experiences tropical and humid climate. The mean daily maximum temperature is in the range of 27.7 °C to 34.0 °C and the mean daily minimum temperature varies between 7.5 °C and 27.8 °C. The annual mean relative humidity is high at 77 per cent. The average annual rainfall is 974 mm. The city witnesses two monsoons annually, namely, south-west monsoon (June to September) and north-east monsoon (October to December).

11.2 BACKGROUND ON HAZARD RISK

The city of Vishakhapatnam is exposed to cyclones, storm surges, floods, earthquake, tsunamis and droughts. Every two to three years, Andhra Pradesh experiences moderate to severe intensity cyclone landfall. According to the Department of Disaster Management, Government of Andhra Pradesh, about 44 per cent of the state is vulnerable to tropical storms and related hazards. Similarly, drought is recognized as one of the most frequent hazards that impacts the state.

Geophysical Hazard

The state of Andhra Pradesh falls in two seismic zones – Zone II and Zone III. Andhra Pradesh experienced three major earthquake events in the state: Vizianagaram (1917 with 5.5 magnitude), Ongole (1967 with 5.4 magnitude), Bhadrachalam (1969 with 5.7 magnitude). These are located in the two major tectonic zones of the state, Godavari valley (Bhadrachalam) where the built-up pressure is occasionally released.

The eastern coastal tract and the adjoining area of the state are characterized by many faults/fractures displaying evidence of seismic activity. There are many NE–SW trending fault-bound basement ridges and depressions traversed by transverse features like the Onglore, Avanigadda, Chintalpudi, Pithapuram and Vijayanagaram cross trends (Source: Earthquake Manual, Revenue (Relief) Department, GoAP). These NE and NW trending discontinuities may be vulnerable to reactivation with progressive build-up of stress. Among these, the most active zone is the Ongole area, which has records of mild earthquakes in the last 30 years.

With coastline of 1030 km, the state is exposed to tsunami risk. During the recent tsunami event (2004), tidal waves ranging from 2 m to 6 m high reached the Andhra Pradesh coast. The tide-gauge at Visakhapatnam port recorded tsunami of 1.4 m high (Singh et al. 2012). According to Singh et al., 2012, the first wave from the source area propagated around the Indian peninsula, and the travel time to Visakhapatnam (17.45 N, 83.20 E) was 2 h 18 min.

Hydro-meteorological Hazard

The Bay of Bengal accounts for 7 per cent of the annual tropical cyclone activity worldwide. The level of human and property loss that cyclones cause around the bay is very high. Cyclonic landfall usually leads to heavy rains, accompanied with high speed winds and eventually translates into floods, as was the case with the damaging cyclone-induced floods in the Godavari delta in August 1986.

Cyclones on the east coast originate in the Bay of Bengal and usually reach the coastline of Andhra Pradesh and Odisha, which are most vulnerable to this type of hazards. Along Andhra Pradesh coast, the section between Nizampatnam and Machilipatnam is most prone to storm surges. In the past, the district of Vishakhapatnam experienced two severe cyclones and seven medium to normal cyclones.

Floods in Visakhapatnam have caused widespread loss to human lives, livestock, damaged homes and caused crop destruction over the decades. Infrastructure damage due floods is well recorded. During the rains of 2005, all the low-lying areas, including Visakhapatnam airport, were immersed in four feet of water. Several families were affected and the flight operations were suspended for about 12 days. Maghadrigedda reservoir is very close to the city and emergency release of water imposes flood-like situation in Visakhapatnam city.

The new city has been developed adjacent to the hillocks and even a light rain causes water to reach the old town area. As 80 per cent of the city has been concreted, the runoff from rain water floods the low-lying areas. To reduce the water logging problem, storm water drains have been constructed at most affected areas like Gnanapuram, Lakshmi talkies and Convent Junction area.

Public Health Risk
Visakhapatnam city is prone malaria outbreak every year and ranks first among other cities within Andhra Pradesh (Kumar and Reddy, 2014). Malaria outbreaks in Visakhapatnam are also closely monitored by the National Malaria Programmes since 1961. According to Kumar & Reddy (2014), Visakhapatnam is one of the major districts of Andhra Pradesh that contributes up to 2 per cent of the annual malaria incidence throughout the country with an Annual Parasite Index (API) of 8.46, 8.35 during 1991–95, 1996–2000 respectively.

According to the available data on malarial disease incidence from the year 1984 to 2009, the highest number of cases were reported in 1999 (i.e., 41,977), followed by a gradual decrease in malaria positive cases till the year 2009 (i.e., 2005). Plasmodium falciparum and P. Vivax infections were predominant in Visakhapatnam.

11.3 BRIEF VULNERABILITY PROFILE

Visakhapatnam is one of the fastest growing cities in the world, both economically and demographically. Visakhapatnam Port is one of 13 major ports of India. It is India's second largest port by volume of cargo handled. It is located on the east coast of India and is located midway between the Chennai and Kolkata Ports. It predominantly caters to petroleum, steel and fertilizer industries. The city is home to Visakhapatnam Steel Plant, Dredging Corporation of India and Hindustan Petroleum. It also has two NTPC power plants to cater to its power needs.

Since the city is prone to natural hazards such as tsunami, cyclones, storm surges and floods (especially urban floods), the vulnerability of the population and infrastructure along its coast is high.

11.4 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.

Meteorological Centre, Indian Meteorological Department (IMD), Hyderabad
Meteorological Centre, Hyderabad, maintains 29 surface observatories (17 departmental and 12 part-time), four pilot balloon observatories, three radiosonde/rawin observatories, five agricultural observatories, 218 rain gauge stations and 35 Automatic Weather Stations.

Met Centre, Hyderabad has state-of-art S-band Doppler Weather Radar that is capable of weather surveillance up to 250 km (maximum up to 500 km) around Hyderabad. It provides imageries derived from volume scan depicting location and intensities of clouds, expected rainfall from these clouds, horizontal winds, wind shear etc. The imageries are very good tools for weather analysis and forecasting. They are automatically updated to IMD's website.

Met Centre, Hyderabad, issues weather warnings to the following, other than IMD: this is also known as album page warnings to relief commissioner, district collectors, fisheries department, railways, intelligence Department (SP Office) AP Police and Doordarshan Kendra.

Cyclone Warning Centre, India Meteorological Department (IMD), Vishakhapatnam
The cyclone warning centre at Kailasagiri, Vishakapatnam, is equipped with state-of-art technology and is manned 24X7 providing weather information at regular intervals. The warning centre currently has Gematronik (Germany) make, S-Band Doppler Weather Radar (DWR) that provides information on weather, especially rainfall and wind speed every 30 minutes for a radius of 200 km to 450 km. During the recent cyclone, Phailin, this centre acted as a command and control centre for the city of Vishakapatnam. Currently, the centre,

along with uploading information on the website, informs key government departments and personal through SMS and email.

The Indian National Centre for Ocean Information Services (INCOIS)
The Indian National Centre for Ocean Information Services (INCOIS) has a mission to provide ocean information and advisory services to the society, industry, government and scientific community through sustained ocean observations. The centre provides storm surge prediction and disaster management, climate/monsoon/weather forecast, monitors pollution/oil spill and takes care of global ocean observation.

INCOIS provides tsunami warning to the State Relief Commissioner or Secretary Disaster Management Department. In Visakhapatnam, INCOIS established Ocean Information System at Fishing Harbour which gives ocean state information, such as wave height and wave direction to the fishermen community.

The Health and Sanitation Department of the Greater Visakhapatnam Municipal Corporation of Visakhapatnam
The health department is responsible for the management of coordinating actions related to solid waste management and bio-medical waste management, medical care, urban malaria scheme, birth and death registration, VACS – AIDS control, implementation of Prevention of Food Adulteration Act, trade licensing and veterinary public health.

Based on the stakeholder consultation, it was evident that much of the public health risks are addressed on a needs basis. They currently use paper-based system and rely on media for information related to outbreak and dissemination of their advisories. Since health and sanitation are together, there was evidence of informal communication and coordinated actions.

Irrigation Department
Andhra Pradesh State Irrigation Department at Visakhapatnam manages and monitors the Meghadrigedda reservoir. The Irrigation Department at Visakhapatnam operates 24 hours EOC during monsoon months. The catchment of Meghadrigedda reservoir covers an area of 374 sq km and covers Visakhapatnam and Vizianagaram districts, Andhra Pradesh.

Disaster Management Department
The department is responsible for preparedness, mitigation, relief and rehabilitation. The functions of the disaster management setup in Andhra Pradesh are as follows:
• Monitoring seasonal conditions.
• Preparing and updating calamity contingency plans for cyclone, flood, drought, earthquake, etc
• Disseminating early warnings in case of threat of calamities such as cyclone and flood.
• Coordinating evacuation/rescue, relief and rehabilitation activities in times of natural calamities.
• Submitting memorandum for assistance from NCCF to the Central Government in case of occurrence of natural calamities; and Coordinating with the Planning Department in preparation of disaster mitigation plan by various line departments.

Fisheries Department
The Fisheries Department plays a major role in the development of the fisheries sector within the State. The main activities of the department include providing preventive and curative health care to livestock by keeping a check on disease outbreaks, providing relief measures to livestock during natural calamities, building awareness and coordinating with the health department in controlling diseases of zoonotic importance.

11.5 INDICATORS OF THE EXISTING CONDITION OF EWS

Table 10: **Criteria development matrix: Indicators of existing condition of EWS in Visakhapatnam**

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)	●	○	○	○	○	The State Plan does not highlight ULB role as a part of EWS
1.2	Institutional mechanism for local authority (ULB) is an integral part of EWS framework (document, mandate, implementation)	●	○	○	○	○	Select departments, such as VPT, have their own DM Plan
1.3	ULB accorded with the authority to disseminate warnings (mandate, SOP, implementation)	●	○	○	○	○	Municipality realizes the need. Process to initiate a change in mandate is yet to take place
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)	●	●	○	○	○	No specific mandate exists for disseminating of warning. Only during the onset of cyclone, warning to low income population residing in risk prone areas is being provided by GVMC

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)	●	●	●	○	○	GVMC authorities indicated the presence of maps of vulnerable/risk-prone hotspots. There was no evidence of physical/virtual maps
2.2	Outreach practice (dissemination of warning)	●	●	○	○	○	Forecast bulletins are provided by IMD to DC, railway, port, telecommunication, fisheries in the event of cyclone, storm surge
2.3	Timely dissemination of warnings to vulnerable groups (residing in slums, high risk prone areas)	●	●	●	○	○	Dissemination of warning exists for cyclone and fluvial floods. Respite time for cyclone is relatively higher than that of fluvial floods. In case of cyclone, gusts providing warning to the fishermen at sea are still a challenge
2.4	Arrangement for night time warning (limited to floods, landslides, cyclones, tsunamis)	●	○	○	○	○	No specific arrangements are in place
2.5	Media engagement in dissemination of warning	●	●	○	○	○	Coverage of information is evident in case of cyclone. Technical information is presented as it is and need for translation into local language is realized
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)	●	○	○	○	○	Limited information is provided to general public by local government. Much of the content is related to advisories than warning. Need for evacuation is provided to public by GVMC during severe cyclone

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)	●	●	○	○	○	Risk prone areas identified based on historical data, past disasters and other qualitative information in the form of institutional memory and tabular records. The HVRA for the city was underway during review
3.2.1	Warning mechanism for geophysical hazards (earthquake)	●	●	●	○	○	Warning mechanism for tsunami does exist. No warning currently is in place for landslide
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. This was also evident from the warning provided during cyclone Phailin. Need for community level warning is realized
3.2.3	Advisory mechanism for public health risks (vector-borne and water-borne diseases)	●	●	●	○	○	The Department of Health is well aware of vulnerable groups which are low income groups and they tend to target their advisories. Active and passive surveillance also exists under IDSP, but no specific attention given to the urban areas
3.3.1	Availability of technology to nowcast/forecast geophysical hazards by technical agencies	●	●	●	●	○	Technology to forecast and nowcast exists for tsunami at state level. No technology currently exists for landslide and earthquake
3.3.2	Availability of technology in nowcast/forecast of hydro-meteorological hazards by technical agencies	●	●	○	○	○	Observations and forecast of cyclone, heavy winds, storm surge, gust and heat waves are currently provided by IMD. The city is benefited by the presence of CWC within its administrative boundary
3.3.3	Disease surveillance system (surveillance coverage, collection method, analysis)	●	●	●	○	○	The health department (district malaria cell) currently monitors and nowcasts disease prevalence at the district level. The use technology is limited to paper-based data collection and manual collation
3.4	Uncertainty in forecast and warning (hydro-met, public health)	●	●	●	●	●	Warning based on forecast exists for hydro-meteorological hazard. In case of public health, warning based on forecast exists with high uncertainty

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	●	○	○	○	○	Budget head does not exist in GVMC. No plan for inclusion in the near future
3.6	Data availability for operations of EWS	●	○	○	○	○	Data are available with different agencies in various formats. GVMC currently operates system for public health data collection only
3.7	Staffing and capacity within local authority for operation and maintenance of EWS	●	●	○	○	○	Staffs are deputed on need basis for risk information communication, collection of information from the ground and evacuation only
3.8	Use of modern technology to disseminate warning (hydro-met, public health)	●	●	●	●	○	Warning system exists for tsunami at the district level with digital display board at one location within the city. GVMC also has vehicle mounted PAS for communicating the warning to the vulnerable community. State-of-art alert and warning system, dedicated weather channel, online dissemination system exist for hydro-met hazards. Doppler radar systems and dedicated state-of-art cyclone warning centre is operational within the city. Information regarding extreme weather events, including the state of the sea is communicated using PAS, digital display, mobile SMS, web and community radio. The use of technology is limited in case of public health risks. Health advisory in case of disease outbreak is communicated through local newspapers and cable channel. Efforts are being made to provide similar information through local radio
3.9	Redundancy (multi-mode) in communication networks	●	●	●	●	○	Multi-mode communication network exists only for cyclone and storm surge hazards
3.10	City Emergency Operations Centre (EOC) for housing data of hazard, vulnerability and risk	●	○	○	○	○	The need of EOC is recognized by GVMC, but currently there are no plans for establishing the same. Post-event temporary EOC becomes operational at the District Collectorate

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	●	○	○	○	○	Health advisory in case of disease outbreak is communicated through local newspapers and cable channel. Efforts are being made to provide similar information through local radio
4.2	Raisng awarenss about warnings at city level	●	●	○	○	○	Awareness and sensitization products were evident for public health risks. People within the city are sensitized to cyclone hazard risks from their past experiences
4.3	Ability of technical agencies and disaster management institutions to cater their early warning products and services to user-specific requirements	●	○	○	○	○	User needs are realized based on the experiences of select few within the administration, but no systematic assessment is currently in place
4.4	Risk communication	●	●	○	○	○	Hazard risk and vulnerability assessment for the city was ongoing during the time of this review

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	●	○	○	○	○	Formal coordination mechanism does not exist in the city. But, informal links exist amongst limited agencies and office of District Collectorate. During discussion, IMD had expressed its willingness to coordinate with the GVMC
5.2	Extent of links between disaster management agencies and service providers	●	●	○	○	○	Formal links do not exist. However, GVMC is informed only during the onset of event by the District Collector Office
5.3	Extent of links between media and disaster management agencies	●	●	○	○	○	Limited information related to early warning is provided to newspapers and local news cable. Local media convert this information in Telugu language

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	●	○	○	○	○	Only GVMC is aware of select early warnings, but impact not clear to initiate action
6.2	Extent to which the warning mechanism allows for feedback from the affected area	●	○	○	○	○	Feedback mechanism is not in place
6.3	Level of reflection and learning evident within local authority	●	●	○	○	○	GVMC has learnt from the experience of the 2013 cyclone and flood events later on. The City Disaster Management Plan and City HRVA are in process
6.4	Monitoring, evaluation and targets for improvement of EWS	●	●	○	○	○	Formal performance monitoring mechanism is not established. However, performance of previous year early warnings discussed during annual monsoon preparation meeting at the District Collector's Office

11.6 SUMMARY

Visakhapatnam city has the presence of key institutions catering to the needs of services in early warning and disaster management. Key institutions include: Cyclone Warning Centre (IMD), Irrigation Department, District IDSP Cell, GVMC Fire Service Department and Indian Navy.

Visakhapatnam District Collector's Office is responsible for providing early warning information to relevant agencies and institutions in its jurisdiction such as GVMC (UMB), Irrigation Department, VPT (Port) etc. GVMC has various departments such as engineering, water supply, sewer and drainage, health and social welfare, responsible for specific tasks within GVMC area. GVMC is responsible for carrying out disaster management activities based on information provided by the District Collector. The District Collector's Office receives regular update and warning from the State Disaster Management Department. Cyclone Warning Centre (IMD) at Visakhapatnam provides early warning to the District Collector's Office.

Irrigation Department provides Meghadrigedda dam water release information four to six hours in advance to the District Collector, VPT, Navy and GVMC. Irrigation Department has installed some rain gauge stations at Meghadrigedda dam site. The department conducts monsoon preparation meetings at city.

City level City Disaster Management Plan (CDMP) and Hazard, Risk and Vulnerability Assessment (HRVA) for Visakhapatnam city are not available. However, GVMC is working on preparing CDMP with HRVA. Hotspots such as low lying areas and shelters will be identified during the study.

The review of city level key institutions brought to the forefront, realization of need for early warning system for hydro-met hazard (especially flood, severe rainfall and cyclone) and also establishment of Emergency Operation Centre (EOC). GVMC (ULB) also realized the need of EOC to support EWS and improving disaster management activities in the city and its planning areas.

District Collector of Visakhapatnam has a hotline connection with Cyclone Warning Centre (IMD) and State Disaster Management Department. The Cyclone Warning Centre has a Doppler radar at Visakhapatnam that provides precise information and near real time warning to DM agencies. INCOIS provides tsunami warning to State Relief Commissioner or Secretary Disaster Management Department. In Visakhapatnam, INCOIS established Ocean Information System at Fishing Harbour, which gives ocean state information; such as wave height, wave direction to the fishermen community.

District Collector calls emergency meeting and assigns specific tasks to relevant agencies after receiving warning from the national and state agencies. District Collector monitors the situation very closely and provides further updates to GVMC, VPT, Navy and Irrigation Department.

The existing methods of dissemination of warning by agencies are through formal mail/fax, that are sent to government departments. The same information is also disseminated to the general public and local media, both print and television.

Cyclone Warning Centre (IMD) transmits standard set of warning messages to relevant agencies. This includes fax messages, SMS and phone calls. During any event, centre also runs 24X7 call centre. However, local level details are not incorporated in hydro-met forecast/warning, which is currently given by the district level Disaster Management Authority to ULB. GVMC uses public address system (PAS) to inform the public. Fishermen communities along Visakhapatnam coast are informed by Joint Director (Fisheries) and also by INCOIS using digital display boards.

Coordination mechanism for early warning system and disaster management in Visakhapatnam is formal. Links are established only via District Collector's Office. GVMC is responsible for informing people and undertaking response actions within corporation boundary. Agencies such as GVMC, Irrigation Department have the experience of handling past events and, therefore, coordination mechanism improvement is based on institutional memories and individuals who have been in the forefront of managing the crisis situation.

There is limited formal feedback mechanism observed in Visakhapatnam city between technical, disaster management agencies and between ULB and communities at risk/city stakeholders. During annual pre-monsoon meetings chaired by District Collector, limited discussion is held on activities planned in the previous year and actions taken in the current season. Establishment of feedback mechanism can improve the current functioning.

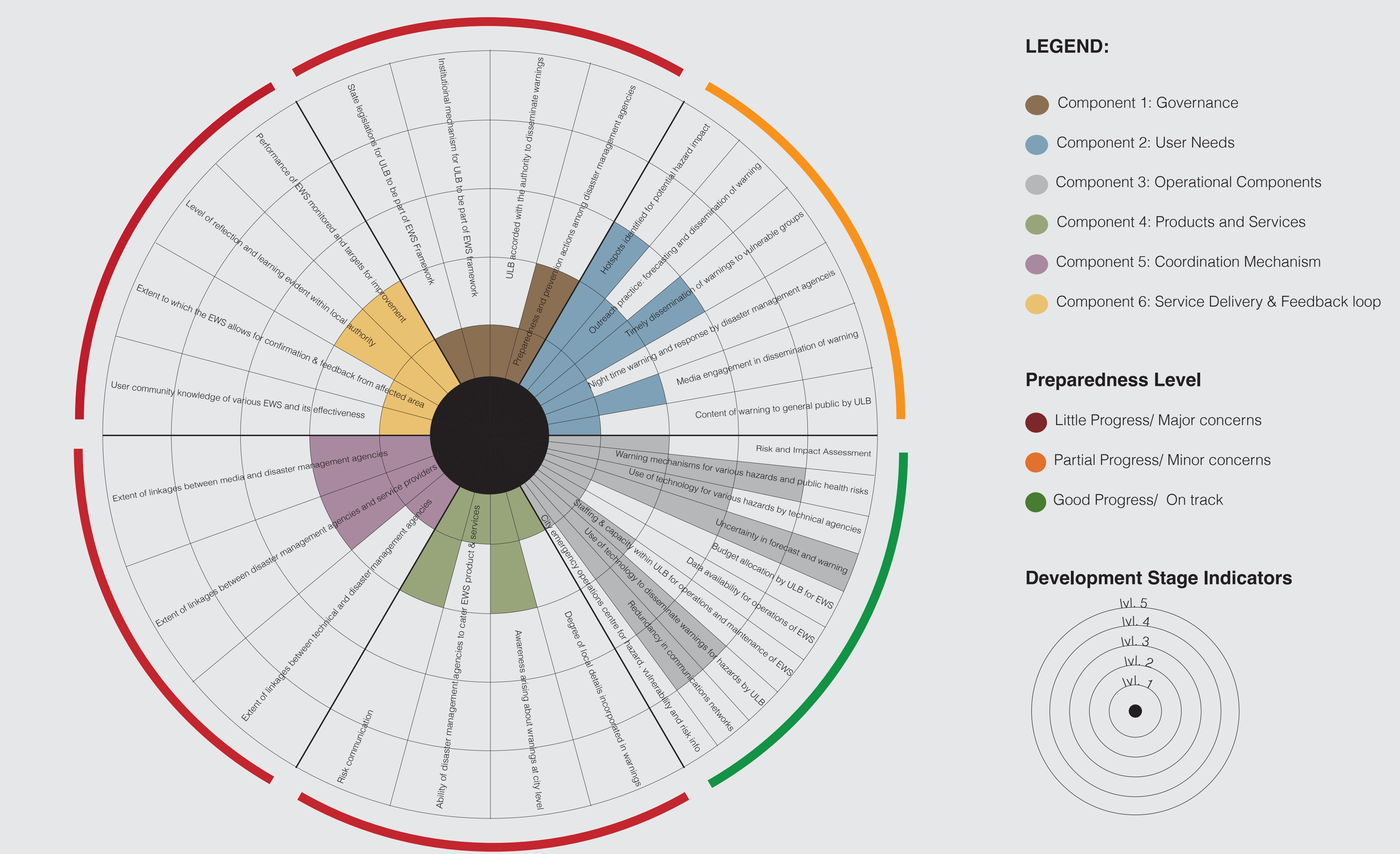


Figure 24: **Preparedness of EWS indicators for Visakhapatnam**

12. RECOMMENDATIONS & OUTLOOK

Initial results of the review have been shared with the cities during discussion meeting with city stakeholders. Stakeholders from the cities have endorsed the results emanating from the review process. The following set of recommendations have been developed and presented for further action:

Recommendations for improving the EWS for Urban Areas

National / State Institutions

1. State DM Plan should entrust ULB with the responsibility of developing city EWS for specific hazards.

2. For an integrated approach, SDMA should provide an enabling platform to debate, increase coordination and strengthen EWS links across all levels of the government, technical agencies (geological, hydro-meteorological, public health risks), private sector, city level institutions and non-government organizations.

3. IMD's Doppler radar system at city level or within the range of the city has proven to be quite beneficial during cyclone. While the plan to have a radar network is underway, fast-tracking of the same is the need of the hour.

4. IDSP's Health surveillances across cities are found to be relatively useful in detecting outbreaks, since they are directly linked to the state department. Currently, the paper-based approach has a turnaround time of 10 to 15 days for actions. Tools for real time monitoring should be considered.

5. Cities (not the state capital) have limited interactions with state agencies. There is need for enhanced coordination mechanism amongst DM Agencies and ULB.

6. There is a need to create discussion platform for deliberation and discussion between technical agencies (IMD, CWC, GSI, CESS, and INCOIS among others), State Departments and the ULB. In addition, there is a need to create an appropriate framework with due legal process to ensure that roles and responsibilities of the agencies are defined and executed.

Urban Local Bodies

7. The ULB/city government should earmark annual budget for development and maintenance of EWS (Capex & Opex).

8. ULB's DRR agenda should encompass EWS as a critical component. The city government should establish and provide operational services and guide the local development agenda/safeguard infrastructure – assets – communities at risk.

9. Institutionalization of EWS within ULB must ensure integration between line departments and technical agencies. Line departments, in turn, must focus on development of appropriate SOPs for EWS.

10. Cities should invest in a fully operation EOC (24X7) to support risk assessment and EWS. Trained manpower must run the centre's operations.

11. Capacity building of ULB/City Government on EWS (technical and management) is crucial for system development and implementation. The ULB should earmark funds for training so as to assist the process of strengthening the EOC, City DM Plan, communities at risk, media, emergency responders and key stakeholders.

12. Awareness programme should aim at strengthening the level of preparedness. The programmes should be contextualized and scenario-based.

13. Networking and involvement with state, regional and national level institutions will strengthen EWS at city level. Networking brings in exchange of observation data, expertise, joint validation of modelling results, improved decision making, sharing of lessons learnt and best practices.

14. The ULB/city government should identify and link technical and resource institutions within the city for EWS operations.

15. A functional EWS puts forth the requirement to harmonize SOPs that determine response. Standardization of departmental plans and terminology ensures effective response actions. SOPs have to be evaluated and modified through conduct of drills.

16. ULB/City Government should develop hazard analysis, vulnerability assessment and risk assessment (on GIS platform). Climate variability and climate change should be an integral part of the risk assessment.

17. To strengthen disaster preparedness and emergency response, it is important to ensure that emergency response actions are guided through scientific and observed data. The city EOC should harmonize flow of information from all agencies and determine potential impact locations within the city

18. ULB/City Government requires real time data for a range of services (traffic, health, services monitoring – water/sanitation/solid waste management). There is a need to design and develop integrated hydro-meteorological, public health and environmental (say, air quality) monitoring systems in close cooperation with technical agencies, disaster risk management agencies and the ULB. Such an integrated system will be cost-effective and will ensure operations at all times.

19. Event preparedness meetings should be regularized: before winter (for snow/cold wave), summer (heat wave) and monsoon season (tropical cyclone). Pre-Monsoon Preparedness Forum has helped several cities minimize the risk (discussions around monsoon outlook, calibration of model results, preparedness plan).

20. Night time warning has to be an integral part of EWS. If need for evacuation arises, additional measures should be stepped in to stage emergency response. The city DM Plan should make a clear provision for night time warning.

21. Relay of warning information should use a wide variety of options. Select hot spot locations should be equipped with sirens. To maximize outreach of warnings to general public places (railway stations, bus stations/stops, important city junctions, city market places, parks etc.), display screens must be positioned with real time information.

22. Engagement of the media is important to build a culture of safety and resilience. An exclusive weather channel is recommended.

23. It is critical for City Government/ULB to invest in city-level climate scoping studies, promote adaptation and resilience measures across key sectors and integrate with DRR and development planning.

Technical Agencies

24. The ULB and allied institutions require support from technical agencies to build the current understanding of hazard risks, DRR options,\ and expand the understanding to incorporate future threats of climate change and other hazards in decision making for new development and public safety.

25. Development of EWS (monitoring, impact forecasting, warning formulation) has to be hazard specific. EWS development should take into consideration predominant hazards and more frequent/less frequent events (but with a potential for severe damage).

26. Despite technical breakthroughs in earthquake EWS (alerts), efforts should be made by technical agencies to implement EWS in high seismic prone cities. Landslide EWS can be successful in conjunction with appropriate selection of land use criteria for landslide prone region, further combined with environmental monitoring of the risk prone areas.

27. Community-based monitoring has proved to be beneficial for management of geological hazards. A combination of technical and community-focused approach should be adopted for implementation.

28. User understanding of the forecast in technical terms is limited. This is evident from the current set of common information products shared with the user community. Therefore, translation of forecast to warning action has to be backed with action-based information in easy understandable language.

29. Warning mechanism should keep focus on communities at risk. A generic city-level warning may not be appropriate, given the diversity of the built environment in urban areas. In addition, customized local warnings have to be provided to hotspot locations.

30. Warning products should clearly indicate threats to the population/stakeholders. Efforts have to be made by the technical and disaster management agencies to tailor the warning that allows not only understanding the potential event but also determining the potent impact. The warning at the city level should highlight societal impacts and not be broad-based. Stakeholders should be able to distinguish between low impact and high impact events. At the city level, there has to be minimum ambiguity in information when shared with the general public. Communities at risk should be able to perceive risk and react appropriately.

31. Simple and easy to use visualization tools should be made available by technical and disaster management agencies to the citizens. This will ensure participation and effective decision-making.

Summary

It is important at this stage to note that EWS in the seven cities 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.

CASE STUDIES FOR ESTABLISHED EWS

Case Study 1: Qinglong County Early Warning Success for M7.8 Earthquake

Photograph: Students in Qinglong County had classes outdoors as the Great Tangshan Earthquake (GTE)

Project title: Community Monitoring and Preparedness for Earthquakes

Location & Country: Northeast China

Hazard type: Earthquakes

Stakeholders: Local communities in China

Period of Implementation: 1966–1980

Contact:
Professor Jean J. Chu
Institute of Geology and Geophysics
Chinese Academy of Sciences (CAS)
Beijing, China
+86-136-9306-7556
E: jeanjchu@gmail.com

Description:
When a strong earthquake killed over 2,40,000 people in Tangshan in 1976, an adjacent county escaped unscathed. All 4,70,000 residents of Qinglong County in the northeast corner of Tangshan survived the magnitude 7.8 quake except for one, who died of a heart attack. Even in Beijing, farther away from Tangshan than Qinglong, hundreds of people were killed by the Great Tangshan Earthquake (GTE). Qinglong, or blue dragon in Chinese, was not invincible to the tremendous power unleashed by this quake, as more than 1,80,000 of its buildings were destroyed, including 7000 which totally collapsed. What saved the day for these rural dwellers was a unique combination of environmental monitoring of nature's signals prior to the quake, and accessing scientific information on precursory changes in electrical resistivity and crustal stress. Local officials and county residents, including schoolchildren, were educated to make sense of all these data, and took effective preparatory measures in time.

Case Study contributed by Prof. Jean Chu

Case Study 2: Community-based Earthquake Monitoring System in Xinjiang

Photograph: Workshops, trains and local communities use computer software to analyse their recorded data

Project title: Community-based Earthquake Monitoring System in Xinjiang (UNDP Project No. CPR/03/612)

Location & Country: Xinjiang Uygur Autonomous Region, China

Hazard type: Earthquake

Stakeholders: Local communities in Xinjiang Uygur Autonomous Region, China

Period of Implementation: April–November 2003

Contact:

Professor Jean J. Chu
Institute of Geology and Geophysics
Chinese Academy of Sciences (CAS)
Beijing, China
+86-136-9306-7556
E: jeanjchu@gmail.com

Description:
On 24 February 2003, a strong earthquake of M 6.8 struck Jiashi County in southwest Xinjiang Uygur Autonomous Region, China. In response, UNDP located funds and worked with China International Centre for Economic & Technical Exchanges (CICETE) and Chinese Academy of Sciences (CAS) to complete a nine-station community-based earthquake monitoring system. This system is presently in full operation and during its first four months was able to see ahead of the M 6.1 earthquake on 1 December 2003, which struck near Bole monitoring station in northwest Xinjiang. Nearly one-third of the staff involved in this nine-station system is women. Public disaster education drives, conducted during the project, involved 50 local government officials and over 700 schoolchildren. The total time taken, from conception to completion of this community-based earthquake monitoring system, was five months (April–September 2003). The project established CSCAN, the Crustal Stress Community Awareness Network, thus improving the capacity of local communities to monitor and prepare for earthquakes.

Case Study contributed by Prof. Jean Chu

Case Study 3: Landslide Early Warning Network

Photograph (L): Installation of the rain gauge by DMR team. Also seen is the local community volunteer as part of the landslide watch network
Photograph (R): Rain gauge with warning thresholds determined for a particular location.
(Location: Mae Phun Sub-district, Lablae District, Uttaradit Province)

Project title: Landslide Early Warning Network

Location & Country: High risk prone areas across Thailand

Hazard type: Landslide

Stakeholders: Department of Mineral Resources, Local communities at risk

Period of Implementation: Ongoing

Contact:
Department of Mineral Resources
Ministry of Natural Resources and Environment
75/10 Rama VI Road, Ratchatewi, Bangkok 10400
www.dmr.go.th

Description:
Department of Mineral Resources has carried out study programmes to gain better understanding of such events and has set up activities for the prevention and mitigation of them via engineering. Most of the works undertaken by DMRs are based not only on scientific approach but also on people's participation. DMR tried to make the best out of limited resources to sustain the geo-hazard management system of the local communities distributed throughout the country. A new concept has been developed under certain key concepts, which are: geological knowledge as a strong foundation, best engineering geological practice, HM King Bhumibhol's sufficient economy, and living in harmony with nature. DMR promotes the role of people and local communities in warning and preparedness of the geo-hazard risk areas. DMR has set up landslide warning networks for both local and regional areas in the high risk areas throughout the country. The network has been set through a series of seminar meetings for capacity building of the local community with the supply of efficient equipment for the network group to be able to monitor rainfall and landslide in their areas. This activity is especially focussed during the rainy season of the year. This work has created awareness among people who have been or potentially been affected by such hazards to be well-prepared for the event that is yet to come.

Case study contributed by Anup Karanth (Field Study undertaken in 2008)
Additional reading reference: Adichat SURINKUM Worawut Tantiwanit Jarin TULYATID, Prevention, Mitigation and Engineering Response for Geohazard in Thailand, Paper in the 6th International Conference in Geotechnical Engineering, Arlington, VA, 11–16 August 2008.

Case Study 4: Flood Control Centre

Photograph: Monitoring Street Flooding
Source: Screen Print of FMS, Last accessed on 20April2014

Facility: Flood Control Centre

Location & Country: Bangkok, Thailand

Hazard type: Flood

Stakeholders: Department of Drainage and Sewerage, Bangkok Metropolitan Administration, Thai Meteorological Department, Department of Disaster Prevention and Mitigation, Traffic Control Centre, Royal Irrigation Department

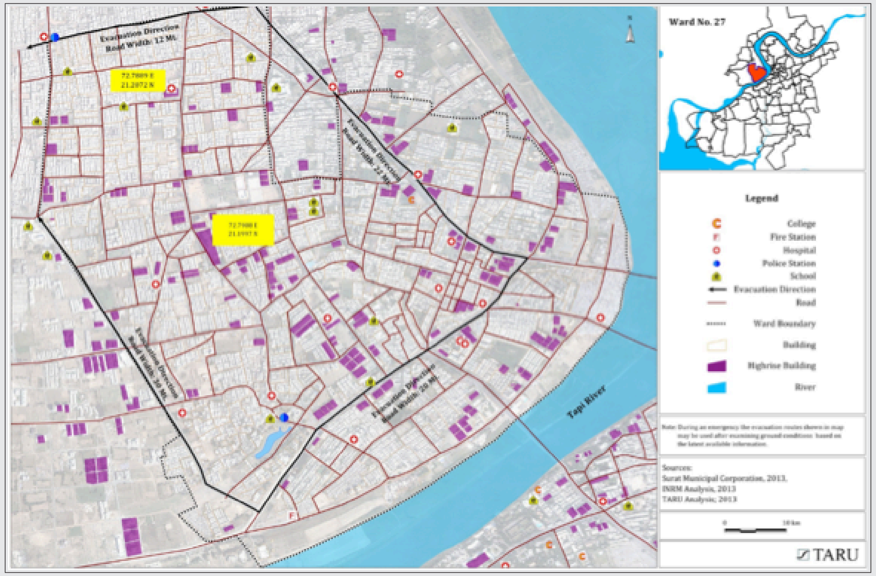
Period of Implementation: Since 2000

Contact: BMA City Hall, Dindaeng, Bangkok, Thailand 10400
http://dds.bangkok.go.th; http://www.bangkok.go.th

Description:
Bangkok Metropolitan Administration has set up Flood Control Centre (FCC). FCC supervises the hydrological conditions linking directly with the radar of Meteorology Department and of BMA. FCC has been serving as a decision-making tool for the Department of Drainage and Sewerage (DDS) flood protection teams for accurate and immediate directive to solve flood problems effectively. Monitoring stations monitor real time data of rainfall, water levels, pumps operation, water gates operation and water quality that are installed. In addition, the department is implementing a flood forecasting programme aiming at forecasting rainfall intensity and flood forecasting in 650 km2 of the east bank area, which will enable BMA staffs to forecast flood condition three to six hours in advance. FCC serves people with flood forecasting news and flood protection and solution. Several communication channels are used to inform people and communities (radio broadcasting, traffic billboards and BMA's website). DDS has weather monitoring system (http://dds.bangkok.go.th/wms/); surveillance radar rain images (http://dds.bangkok.go.th/Radar/radar.htm); flood monitoring system (http://dds.bangkok.go.th/Floodmon/); water measurement system/canal overflow (http://dds.bangkok.go.th/Canal/); SCADA system (http://dds.bangkok.go.th/scada/); and plan to prevent and resolve flooding, among others.

Case study contributed by Anup Karanth (Institutional Landscaping Exercise for EWS, 2008)
Reference: http://www.unisdr.org/campaign/resilientcities/cities/view/28

Case Study 5: End-to-End Early Warning System for Ukai and Local Floods



Evacuation mapping for Ward 27 in Surat City

Project title: End-to-End Early Warning System for Ukai and Local Floods

Location & Country: Surat, India

Hazard type: Floods

Stakeholders: Surat Municipal Corporation, Surat Climate Change Trust, India Meteorological Department, TARU Leading Edge

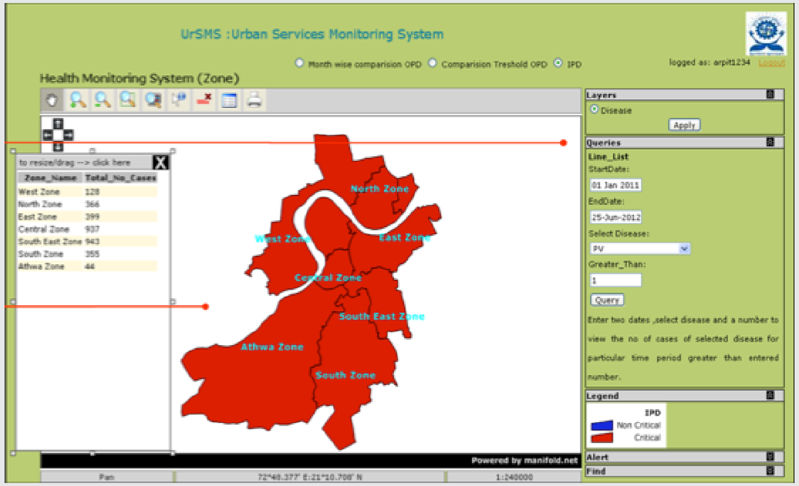
Period of Implementation: 2011–2015

Contact:
Surat Climate Change Trust,
Muglisara, Main Road,
Surat – 395003 Gujarat, India
www.sccctrust.in

Description:
Over the past two decades, the flood frequency is increasing due to increased variability of rainfall (extreme events), especially within the Tapi river catchment. An End-to-End Early Warning System (an initiative under the Asian Cities Climate Change Resilience Network) has been established in the city of Surat to manage floods caused by extreme precipitation events in the Upper and Middle Tapi basin as well as khadi (tidal creeks) floods. The main objective of this project is to reduce the intensity of floods and resultant flood damage to Surat through improved reservoir operation to minimize peak floods and systems to enable institutions and society to handle flood emergencies. Key project components include: developing management framework for EWS; establishment of Surat Climate Change Trust and Technical Committee, climate change informed hydrological and hydraulic modelling, early warning and disaster management system, integration with City Disaster Management Plan, information and support for the poor and sustainability arrangements. The establishment of the warning system includes the installation of weather systems, data transfer mechanism from catchment to reservoir to city, development of weather and flow prediction models, improvement of existing flood preparedness and action plans.

Reference: Asian Cities Climate Change Resilience Network, www.acccrn.org

Case Study 6: Urban Services Monitoring System



Photograph: Screen Print of Urban Services Monitoring System

Project title: Urban Services Monitoring System (Health Component)

Location & Country: Surat, India

Hazard type: Diseases

Stakeholders: Health Department (Surat Municipal Corporation), TARU Leading Edge

Period of Implementation: 2009–2013

Contact:
Surat Municipal Corporation
Muglisara, Main Road,
Surat – 395003 Gujarat, India
www.suratmunicipal.gov.in; http://surat.ursms.net/cms/home.aspx

Description:
High density, lack of safe water supply and its location on a river side, combined with high temperatures and humidity, changing rainfall patterns, rapid urban growth and industrial development make Surat highly conducive to vector-borne and water-borne diseases. Real time structured data collection from different health institutions, including Urban Health Centres (UHCs), government and private hospitals, laboratories and private practitioners and its efficient analysis were the key challenges faced by Health Department, Surat Municipal Corporation. To overcome the above challenge, short message service (SMS)-enabled integrated Urban Services Monitoring System (UrSMS) was conceptualized and developed for the Surat Municipal Corporation. This system brings resilience to disease monitoring framework by providing timely information on the quality of water supplied from distribution stations and occurrence including outbreak of diseases within Surat. The near real time data collection and analysis is currently helping the health department predict disease outbreaks based on number/distribution of cases across the city and enables them take prompt action to prevent further spreading. The system provides better visualisation of data and integration with ongoing government programmes/ schemes. So far, the system has been able to significantly reduce the number of patients affected by malaria, dengue and leptospirosis.

Reference: Asian Cities Climate Change Resilience Network, www.acccrn.org

REFERENCES

Arbind K Sinha and Shirish U Avrani (1984), The disaster warning process: A study of the 1981Gujarat cyclone. Disasters//1/1984

Analysis of the 2006 WMO Disaster Risk Reduction Country-level Survey

City Disaster Management Plan Madurai

City Disaster Management Plan, City Disaster Management Cell, Municipal Corporation Shimla, prepared under the GoI, UNDP Urban Risk Reduction Project (2009-12)

City Disaster Management Plan 2011, City Disaster Management Cell - Corporation of Thiruvananthapuram

David Rodgers & Vladimir Tsirkunov GFDRR (2011), Implementing Hazard Early warning Systems

Dennis Parker - Flood Hazard Research Centre, Middlesex University (2000), Criteria for Evaluating the Condition of a Tropical Cyclone Warning System, Disasters, 1999, 23(3): 193-216

Draft Disaster Management Plan 2011-12, Bhubaneswar Municipal Corporation

Forecasters Guide (2008), India Meteorological Department

Future Proofing Indian Cities, Draft Urban Diagnostic for Madurai, prepared by ATKINS India, CDKN, IIHS, UCL Oct 2013)

Gangtok City Disaster Management Plan

India Tsunami Early Warning Centre (INCOIS) – User guide

Inventory and GIS Mapping of Landslides in North, East, West and South Sikkim & its Mitigation, Published by Sikkim State Disaster Management Authority, Land Revenue & Disaster Management Department, Govt of Sikkim

Jaiswal, K. S., and Sinha, R. (2007). Probabilistic seismic hazard estimation of Peninsular India. Bulletin of the Seismological Society of America, 70, 1337–1356.

Jaiswal R. K. and B. K. Rastogi, (2006). Tsumamigenic sources in the Indian Ocean, 6th Asian Seismological Commission (ASC) General Assembly – 2006, Symposium on Earthquake and Tsunami Disaster Preparedness and Mitigation, (Abstract Id O019, Session: Subduction Zone, Seismology and Tsunami), November 7-10, 2006 Bangkok, Thailand, pp 84-85.

Kerala State Action Plan on Climate Change, Department of Environment and Climate Change, Govt of Kerala (June 2013)

Kristie L.Ebi and Jordana K schmier (2005), A Stich in Time: Improving Public Health Early Warning Systems for Extreme Weather Events,Epidemologoc Reviews Vol 27, 2005. DOI: 10.1093/epirev/mxi006

Multi-Hazard Risk and Vulnerability Assessment of Gangtok Municipal Corporation Area, Published by Sikkim State Disaster Management Authority, Land Revenue & Disaster Management Department, Govt of Sikkim (2012)

Multi-Hazard Risk and Vulnerability Assessment of North, East, West and South Sikkim, Published by Sikkim State Disaster Management Authority, Land Revenue & Disaster Management Department, Govt of Sikkim (2012)

Preparedness for Disaster and Health Care Management, Directorate of Health Services Trivandrum

Review of City Disaster Management Plan of 6 cities (Gangtok), prepared by Integrated Research & Action for Development (2013)

Seismic Hazard Microzonation Atlas of the Sikkim Himalaya, prepared by Sankar Kumar Nath,

Seismology Division, Department of Science and Technology, New Delhi (2006)

Shahr Apathi Vyavasthan, Vol-1, Navi Mumbai Municipal Corporation (2013)

Shahr Apathi Vyavasthan, Vol-2, Navi Mumbai Municipal Corporation (2013)

Strengthening Multi-Hazard Early Warning Systems and Risk Assessment in the western Balkans and Turkey, Assessment of Capacities, Gaps and Needs. World Meteorological Organization (2012)

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.

Wurman, G., R. M. Allen, and P. Lombard (2007), Toward earthquake early warning in northern California, J. Geophys. Res., 112, B08311, doi:10.1029/2006JB004830

ANNEXURE

List of Agencies and Key Informants Consulted in the Review Process

Bhubaneshwar

Key Informant	Position	Department/ Organization
Dr Kamal Lochan Mishra	General Manager	Odisha State Disaster Management Authority
B N Mishra	Expert and Environment Specialist	Odisha State Disaster Management Authority
Dr Sarat Chandra Sahu	Director in-Charge	Meteorological Centre, India Meteorological Department, Bhubaneswar
S K Dastidar,	Assistant Meteorologist	Meteorological Centre, India Meteorological Department, Bhubaneswar
Meghanad Behera	City project Coordinator	UNDP India
A K Pradhan		Central Water Commission
Atul Kumar Nayak	Superintending Engineer, Hydrological Observation Circle	Central Water Commission
Group of Engineers & Specialists		Central Water Commission
Pravat Ranjan Mohapatra	Deputy Relief Commissioner	Special Relief Commissioner Office, Bhubaneswar
Er Shatrughna Das	Additional Chief Engineer Irrigation, Chief Engineer and Basin Manager (Lower Mahanadi Basin)	Department of Water Resources
Gopal Prasad Roy	Deputy Director, Flood Cell	Department of Water Resources
Dr Chandrika Prasad Das	City Health Officer	
	Bhubaneswar Municipal Corporation	
Binaya Kumar Das	Asst Commissioner (Slum)	Bhubaneswar Municipal Corporation
Pradeep Kumar Sahoo	Emergency Officer	District Collectorate, Khordha
Niranjan Sahu	Collector Khorda District	Dictrict collectorate, Khordha

Key Informant	Position	Department/ Organization
Dr E Venkata Rao	Associate Professor, Department of Community Medicine,	Institute of Medical Sciences & SUM Hospital, Bhubaneswar
Prof Trilochan Sahu	Professor and Head, Community Medicine, Institute of Medical Sciences & SUM Hospital, Bhubaneswar (Ex-Director, State Institute of Health and FW/ Ex-Superintendent, SCB Medical College Hospital, Cuttack)	Institute of Medical Sciences & SUM Hospital, Bhubaneswar
Team of Doctors		Institute of Medical Sciences & SUM Hospital, Bhubaneswar
Dr Prameela Baral	Deputy Director, IDSP	Directorate of Health Services
Dr Bikash Patnaik	State Nodal Officer (IDSP),	Directorate of Health Services

Gangtok

Key Informant	Position	Department/ Organization
Keshav Koirala	City Project Coordinator	SSDMA/Land Revenue & Disaster Management Department
T W Khangsarpa	Additional Secretary/SPO	SSDMA/Land Revenue & Disaster Management Department
G C Khanal	Joint Director	SSDMA/Land Revenue & Disaster Management Department
K S Topgay, IAS	Relief Commissioner cum Secretary	Land Revenue & Disaster Management Department
Sonam D W Chankapa	Special Secretary cum Director	Land Revenue & Disaster Management Department
A K Singh, IAS	Joint Secretary, Planning &	
Former District Collector, East	State Planning Department	
Anil Raj Rai	Municipal Commissioner	Gangtok Municipal Corporation (GMC)
H. K. Chettri	Deputy Municipal Commissioner	Gangtok Municipal Corporation (GMC)
Sangay G. Bhutia	Assistant Municipal Commissioner	Gangtok Municipal Corporation (GMC)
Kapil Meena, IAS	Additional Collector, East District	District Collector Office, East Sikkim
Sonam Wongyal Lepcha	District Project Officer	District Collector Office, East Sikkim
Bijayata Kharel	Training Officer	DDMA/East District
Dinker Gurung	Town Planner, Nodal Officer for RAY, Sikkim	Urban Development Department
S K Shihal	Secretary	Science and Technology Department
D G Shestra	Additional Secretary	Science and Technology Department

Key Informant	Position	Department/ Organization
Narpati Sharma	Asst. Scientific Officer	Science and Technology Department
A K Sharma	Additional Director	Mines and Geology Department
G T Lepcha	Joint Director	Mines and Geology Department
Dr V Singhi	Principal Director	Health Department
A Das	Assistant Meteorologist	Meteorological Centre, IMD
A K Saha	Assistant Meteorologist	Meteorological Centre, IMD
Kailash Agarwal	Hon. Secretary	Sikkim Chamber of Commerce and Industries
Shakti Singh Chaudhary	Deputy Mayor	Gangtok Municipal Corporation (GMC)
Gozin Lachenpa	Superintending Engineer	Irrigation and Flood Control Department
Jigme Wangyal Bhutia	Executive Engineer	Irrigation and Flood Control Department
T T Bhutia	Chief Engineer	PHE & Water Supply Department
A K Agarwal	Superintending Engineer	Central Water Commission, Gangtok
Bhupendra Sharma	-	-

Madurai

Key Informant	Position	Department/ Organization
Vanitha Selvarajan	City Project Coordinator	UNDP/ Madurai Corporation
Leela	Municipal Commissioner (I/C)	Madurai Corporation
Dr Vignesh	Assistant City Health Officer	Madurai Corporation
Dr Yasotha	City Health Officer	Madurai Corporation
Dr A Mathuram	City Engineer & Assistant Commissioner (North Zone)	Madurai Corporation
Arasu	Executive Engineer	Madurai Corporation
Rajendran	Executive Engineer	Madurai Corporation
Jaisheelan	Executive Engineer	Madurai Corporation
Chandrashekharan	Executive Engineer	Madurai Corporation
Chinnama	Assistant Commissioner (East Zone)	Madurai Corporation
V Shiva Subramanian	Sanitary Inspector	Madurai Corporation
Ilayaraja	Sanitary Inspector	Madurai Corporation
Meeting with 22 Key Officials	Various Positions	Madurai Corporation
Dr L Subramanian, IAS	District Collector & District Magistrate, Madurai District	Madurai District
E Thamilarasan	Chief Engineer, PWD (Water Resource Organisation)	Madurai Division
C Cyril Christopher	Chief Engineer, PWD (Building)	Madurai Division
S Rehobayam	Assistant Commissioner (West Zone)	Madurai Division
Devadoss	Assistant Commissioner (South Zone)	Madurai Division
M P Vasimalai	Executive Director	DHAN Foundation

Key Informant	Position	Department/ Organization
Madhan Kumar A	Programme Head (Centre for Research and Development)	DHAN Foundation
Akila Devi	Community Mobiliser (CM)	DHAN Foundation
V V Rajan Chellappa	Worshipful Mayor	Madurai Corporation
Dr Victor T J	District Malaria Officer	Madurai District
Meeting with 80 Key Engineers	PWD, Madurai Division	Madurai Division

Navi Mumbai

Key Informant	Position	Department/ Organization
Shreedutt Kamat	Consultant	DM Cell/NCRMP
I A Kundan, IAS	Secretary, Disaster Management	Disaster Management Unit
Dr P Awate	SSO	IDSP Mumbai
Prof Kapil Gupta	Professor	IIT Bombay
V K Rajeev	Director, IMD, Mumbai	IMD Mumbai
N Y Apte	Deputy Director General, IMD, Mumbai (Retd.)	
K S Hosalikar	Deputy Director General	IMD Mumbai
Dr Jaideep Vishave	DDMO, Thane District	District Collectorate, Thane
Ashok Ghule	Consultant, DM, Thane District	District Collectorate, Thane
P Velrasu, IAS	District Collector, Thane	District Collectorate, Thane
S C Mohanty	Disaster Management Expert	
Chetan Patil	Head	RDMC, NMMC
J N Sinnarkar	Deputy Commissioner	NMMC
R D Nikam	Chief Health Officer	NMMC
Dr Ratnesh Mahate	Health Officer (Epidemic Control)	NMMC
Dr Vaibhav Zunjare	Veterinary Health Officer (Leptospirosis)	NMMC
H R Suthar	Chairman	Vashi Fishermen's Co-Op Soc. Ltd.

Shimla

Key Informant	Position	Department/ Organization
Amandeep Garg	Special Secretary (Revenue-DMC)	Department of Revenue
Dinesh Malhotra	Deputy Commissioner, District Shimla	Deputy Commissioner Office
Neeraj Kumar	Additional District Magistrate, District Shimla	Deputy Commissioner Office
Tikender Panwar	Deputy Mayor	Municipal Corporation Shimla
Naresh Thakur	Assistant Commissioner	Municipal Corporation Shimla
Dr Suresh C. Attri		
	Principal Scientific Officer (Environment)	Department of Environment, Science and Technology
Dr Rajesh Guleri	SSO	IDSP, Directorate of Health Services; Officer on Special Duty NRHM
Dr Umesh K. Bharti	Medical Health Officer	Municipal Corporation Shimla
Harminder Dutta	Scientific Assistant	Meteorological Centre (IMD) Shimla
Rajneesh Sharma	Geologist	Department of Industries
Dr S S Negi	Director	Department of Environment Science and Technology
Dr Kamraja Kaisth		State Council for Science Technology and Environment
Navneey Yadav	Consultant	TARU Leading edge Pvt. Ltd.
Bhavna Karki	City Project Coordinator	UNDP India

Thiruvananthapuram

Key Informant	Position	Department/ Organization
Dr G Sankar	Scientist	Centre for Earth Science Studies (CESS)
Dr K V Thomas	Scientist	Centre for Earth Science Studies (CESS)
P Sudeep	Registrar	Centre for Earth Science Studies (CESS)
Sheela Nair	Technical Officer	Centre for Earth Science Studies (CESS)
Ad Chandrika	Hon. Mayor	Thiruvananthapuram Corporation
G Happy Kumar	Hon. Deputy Mayor	Thiruvananthapuram Corporation
Venkatesapathy S, IAS	Secretary (Municipal Commissioner)	Thiruvananthapuram Corporation
G Padmakumar	Additional Secretary (Deputy Municipal Commissioner)	Thiruvananthapuram Corporation
Ananda Raju	Executive Engineer (City Engineer)	Thiruvananthapuram Corporation
Ansar B.	Assistant Executive Engineer (Assistant City Engineer)	Thiruvananthapuram Corporation
Ramesh Krishnan	City Project Coordinator	UNDP (CRM Programme)
Vijiajithhi R.	CDE	UNDP (CRM Programme)
Shainu Mohan	Reporter	Deccan Chronicle (News Paper)
K. Santosh	Director	IMD, Thiruvananthapuram
S Sudevan	Scientist-D	IMD, Thiruvananthapuram
CaptbHari A Varrier	Technical Officer	Ports Department
M C Mohandas, IAS	Secretary	Kerala State Disaster Management Authority (KSDMA)

Key Informant	Position	Department/ Organization
Keshav Mohan	Director	Institute Land and Disaster Management (ILDM)
Dr Shekhar Lukose Kariakose	Head (Scientist)	HVRA Cell (KSDMA)
Dr Thara K G	Head	Disaster Management Centre, ILDM
D P Srikumar	Deputy Director	Mines and Geology Department
Gopkumar	District Geologist	Mines and Geology Department
Dr Suresh Francis	Scientist	Kerala State Remote Sensing & Environment Monitoring Centre
K A Saira Banu	Deputy Director	Fisheries Department
Ignatius Manroe	Deputy Director	Fisheries Department
Smitha	Deputy Director	Fisheries Department
G. Kamalavardhan Rao, IAS	Secretary	Revenue Department
Suresh	Assistant Secretary	Kerala State Disaster Management Authority (KSDMA)
K N Satheesh, IAS	District Collector and District Magistrate	Thiruvananthapuram District
Dr C K Jagadeesan	Assistant Director	Health Department
Dr Srikanthan	Epidemiologist	Health Department
Dr Susan	District Surveillance Officer	Health Department
Dr Umar Farukh	State Entomologist	Health Department
Dr Suresh Chandra	Director	Geological Survey of India
Dr M. R. Ashok Kumar	Sr. Geologist	Geological Survey of India
Princy	Geologist	Geological Survey of India

Key Informant	Position	Department/ Organization
Dr Ummu Selama	Municipal Health Officer	Thiruvananthapuram Corporation
Dr P Srikantan Nair	Director	Environment and Climate Change Department
P Lathika	Chief Engineer	Irrigation Department
Vijayshree	Deputy Executive Engineer	Irrigation Department
P Anil Kumar	Suprintending Engineer	Irrigation Department

Visakhapatnam

Key Informant	Position	Department/ Organization
Dr K Ramchandra Rao	Director, IMD	Cyclone Warning Centre, IMD, Visakhapatnam
G S L N Murthy	Assistant Director (IMD)	Cyclone Warning Centre, IMD, Visakhapatnam
M V Satyanarayana, IAS	Municipal Commissioner	GVMC, Visakhapatnam
Nagendra Kumar Biyani	Additional Commissioner (F&IT), SPO, UNDP	GVMC, Visakhapatnam
G V S S Murthi	Additional Commissioner (General)	GVMC, Visakhapatnam
M Satyanarayana Raju	Chief Medical and Health Officer, GVMC	GVMC, Visakhapatnam
P Appala Naidu	District Health Officer (Malaria)	District Health Department, Visakhapatnam
Appa Rao	HR Officer	GVMC, Visakhapatnam
Srinivas	Consultant, GVMC Call Centre	GVMC, Visakhapatnam
M Srihari Jagannath	Chief Fire Officer	GVMC, Visakhapatnam
Krupa Varam Ch	District Fire Officer	The Andhra Pradesh State Disaster Response and Fire Services Department (APSDR&FSD)
Murli K.	Scientific Officer (Radar Centre)	Cyclone Warning Centre, IMD, Visakhapatnam
Solomon Arokiaraj, IAS	Collector and District Magistrate	Visakhapatnam District
P Koteshwar	Joint Director	Fisheries Department
Laxman Rao P	Fisheries Development Officer	Fisheries Department
GVL Satyakumar	Vice Chairman	Visakhapatnam Port Trust
B Jayarami Reddy	Chief Engineer	GVMC, Visakhapatnam
S Suribabu	Media Person	ENADU News Paper
Rajendra Kumar M	Deputy Executive Engineer	Irrigation Department, Visakhapatnam

Key Informant	Position	Department/ Organization
Dr Sudhakar Rao	Director, Met Center, Hyderabad	Met Center, IMD, Hyderabad
Dr Y K Reddy	Sr. Scientist- Doppler Radar, Hyderabad	Met Center, IMD, Hyderabad
Dr K Sitaram	Scientist-E, Flood Met Officer, Hyderabad	Met Center, IMD, Hyderabad
Dr T Srinivas	Scientist-F	INCOIS, Hyderabad
Ravi K	Scientist	INCOIS, Hyderabad
C Parthasarathi, IAS	Commissioner	Disaster Management Department, Hyderabad
M Jagannadham, IAS	Additional Commissioner	Disaster Management Department, Hyderabad

Other Key Individuals

Key Informant	Department/ Organization
G Padmanabhan	UNDP India
Ashok Malhotra	UNDP India
Abha Mishra	UNDP India
Reshmi Theckethil	UNDP India
Sanjay Aggarwal	Director, Ministry of Home Affairs
Dr M Mohapatra	India Meteorological Department
Dr B K Bandyopadhyay	India Meteorological Department
Dr S B Tyagi	India Meteorological Department
Dr Kamaljit Ray	India Meteorological Department
Dr Kishore Kumar	Chief Scientist, Central Road Research Institute