Disaster Risk Reduction: A Handbook for Urban Managers

Building Materials & Technology Promotion Council, New Delhi

सत्यमेव जयते

Ministry of Housing & Urban Poverty Alleviation Government of India

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United Nations Development Programme, New Delhi

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New Delhi

एम. वेंकैया नायडु
M. VENKAIAH NAIDU

शहरी विकास,
आवास और शहरी गरीबी उपशमन एवं
सूचना एवं प्रसारण मंत्री
भारत सरकार
MINISTER OF URBAN DEVELOPMENT,
HOUSING & URBAN POVERTY ALLEVIATION
AND INFORMATION & BROADCASTING
GOVERNMENT OF INDIA

MESSAGE

Historically, India has been prone to the occurrence of damaging earthquakes, floods, cyclones and landslides in different parts of the country which have resulted into damage or loss of lives and housing stock. Due to increased need of developmental activities and population explosion, exposure, scale and impact of natural hazards have increased considerably during past three to four decades.

Disaster risks in the country are further compounded by increasing vulnerabilities related to ever growing population, unplanned and increasing urbanization, development with high risk zones, environmental degradation climate changes etc. Due to lack of adequate or no land use restrictions in the hazard prone areas, cities tend to expand in all directions, occupying even most vulnerable areas resulting in vulnerability of more and more areas getting threatened by natural hazards.

The enactment of Disaster Management Act 2005 has brought a paradigm shift in the national policy from relief centric approach to pro-active holistic and integrated approach aimed at inculcating a culture of preparedness, promoting innovative strategies of mitigation and emergency response.

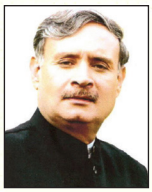
It is important that multi-disciplinary and multi-sectoral approach is taken to incorporate Disaster risk reduction strategies in the development plans. There is a need to strengthen the skill and knowledge base of our urban managers and professionals in integration of disaster risk reduction for planning and implementation of projects under Pradhan Mantri Awas Yojana (Urban) besides other schemes of Government of India.

I hope this Handbook will be useful for Urban Managers in building their capabilities in the area of disaster risk reduction and climate change adaptation. I commend the efforts of officials of my Ministry, UNDP and BMTPC in bringing out this publication.

(M. Venkaiah Naidu)

Office : Room No. 104-C, Nirman Bhawan, New Delhi-110108; Tel. : 011-23061166, 23061162, 23062089 (Fax)
Residence : 30, Dr. APJ Abdul Kalam Road, New Delhi-110011; Phone : 011-23019387, 23019388 (Telefax)

राव इन्द्रजीत सिंह
RAO INDERJIT SINGH



सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर

राज्य मंत्री (स्वतंत्र प्रभार)
योजना मंत्रालय तथा राज्य मंत्री, शहरी विकास
एवं आवास और शहरी गरीबी उपशमन मंत्रालय
भारत सरकार, नई दिल्ली–110001
Minister of State (Independent Charge) for
Ministry of Planning and MoS for Ministry
of Urban Development and Ministry of
Housing & Urban Poverty Alleviation,
Government of India, New Delhi-110001

MESSAGE

As we all know, India is vulnerable to number of natural disasters due to various geo-climatic factors affecting various parts of the country. There is also an increasing trend of these disasters which is a matter of concern for the Government. Recent surge in urbanization, demands a holistic approach towards disaster mitigation and management. Apart from engineers, policy makers and other stakeholders also need to be educated and trained in this area.

I am glad that the Ministry of Housing and Urban Poverty Alleviation, in association with Building Materials & Technology Promotion Council (BMTPC) and UNDP, has prepared a handbook on Disaster Risk Reduction for Urban Managers. I compliment the team of officers for bringing out this publication.

I am sure this handbook will be useful for Municipal Commissioners and other Policy Makers for planning and implementation of disaster mitigation measures in their cities and towns.

(Inderjit Singh)

Office: 132-C, Nirman Bhawan, New Delhi-110011
Tel: 011-23061999, 23063898, Fax: 23061103
mos.ud@nic.in

Residence: 6, Lodhi Estate, New Delhi-110003
Telefax: 011-24643265, 24643266

डॉ. नंदिता चटर्जी, आई.ए.एस.
Dr. N. CHATTERJEE, I.A.S.

Tel. : 011-23061444
Telefax : 011-23061991
E-mail : secy-mhupa@nic.in
Website : http://www.mhupa.gov.in

सत्यमेव जयते

सचिव
भारत सरकार
आवास और शहरी गरीबी उपशमन मंत्रालय
निर्माण भवन, नई दिल्ली-110011
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF HOUSING
& URBAN POVERTY ALLEVIATION
NIRMAN BHAWAN, NEW DELHI-110011

Dated: 2nd December, 2016

Message

India is vulnerable to large number of natural disasters such as earthquake, cyclone, flood, landslide, tsunami and forest fires. Nearly 59% of the area of the country is vulnerable to damage due to earthquake of moderate to severe intensities, 8.5% area is liable to damage due to cyclonic and wind storm surges and 5% is prone to floods. The vulnerability of human settlements is continuously on the rise due to concentration of population and economic activities in large agglomerations.

The risks from natural hazards vary from region to region depending upon geological locations, vulnerability and levels of preparedness. A natural hazard becomes a disaster when it surpasses the social, economic and technical abilities of the affected population, communities, structures or region to cope with the impact and their ability to recover.

The major concern for urban Disaster Risk Reduction ultimately revolves around three issues i.e., improving preparedness, reducing vulnerability in the urban centres and developing policies & mechanisms for mitigating risk. Hence, compliance to design codes alongwith building professionals internalizing their need for safety against natural disasters are necessary to address disaster risks reduction. Building professionals will be able own such disaster preparedness only through education.

No development will be sustainable unless disaster risk reduction (DRR) is built into the development process. It is envisaged that investment in DRR are much more cost effective than expenditure on relief and rehabilitation. Professionals, particularly urban managers involved in planning and implementation of projects in various schemes will need to put in their best efforts towards safety of buildings during possible future earthquake, and eventually eliminate loss of life due to building collapse.

I am happy that the Handbook for Urban Managers on Disaster Risk Reduction has been brought out to serve as a handy tool towards risk sensitive planning and in ensuring safety against disasters.

(N. Chatterjee)

राजीव रंजन मिश्रा,
Rajiv Ranjan Mishra, I.A.S.
संयुक्त सचिव (आवास)
Joint Secretary (Housing)
Tel.: (011) 23061665
Telefax : (011) 23061497
email: jshousing-mhupa@nic.in

सत्यमेव जयते

भारत सरकार
आवास और शहरी गरीबी
उपशमन मंत्रालय
निर्माण भवन, नई दिल्ली-110011
GOVERNMENT OF INDIA
MINISTRY OF HOUSING &
URBAN POVERTY ALLEVIATION
NIRMAN BHAWAN, NEW DELHI-110011

MESSAGE

The Indian sub continent being highly prone to natural hazards, the local bodies have traditionally been involved in disaster management. The occurrences of natural disasters of various forms like earthquakes, floods, hail storms, drought, heat waves and recently flash floods have resulted in huge loss of life & infrastructure. To minimize these losses which are primarily on account of poor planning, design & construction practices, the focus now is increasingly shifting to disaster risk reduction (DRR).

The disaster risk reduction is an elaborate scientific process with hazard risk vulnerability analysis of a specific area/urban local body as first step. The analysis does help in risk sensitive planning in all new development works & formulating strengthening/ retrofitting measures for existing structures. As it involves the role of various stakeholders including professionals, urban managers, elected representatives & common person, the capacities at each level need to be enhanced suitably. A techno-legal regime for disaster risk reduction needs to be in place with suitable mechanism for enforcement of the same.

The urban manager needs to have adequate exposure to all steps of disaster risk reduction as it is one of the crucial aspects of urban management. Keeping this in mind, the Ministry of Housing & Urban Poverty Alleviation, Govt. of India has taken initiative to prepare the Hand Book for Urban Managers with the help of experts from United Nations Development Programme (UNDP) & Building Materials & Technology Promotion Council (BMTPC). It covers all the aspects as highlighted above with case studies presented to cite good practices undertaken in risk sensitive urban planning.

I sincerely hope that Urban Managers would find the handbook very useful & it will go a long way in making disaster resilient India.

(Rajiv Ranjan Mishra)

Empowered lives. Resilient nations.

MESSAGE

The future we want depends largely on the resilience of our cities. More than half of humanity lives in cities and by 2030, 6 out of 10 people will live in cities. The importance of urban centres as engines of growth is critical. In India for example, 80 percent of the decline in poverty levels over the last decade can be attributed to urban growth.

As our cities have grown, so too has the pressure on them and those entrusted with ensuring basic services such as urban local bodies. In addition to ensuring quality services for all, cities face the growing threat of disaster. Over the past three decades, the Asia Pacific has witnessed the sharpest rise in disasters, resulting not just in widespread damage and loss to physical infrastructure, but also to the socio-economic condition of people.

Climate change is expected to increase temperature, uncertainties in rainfall and sea level rise. Urbanization can further amplify the climate variability impacts, resulting in additional stresses on already inadequate infrastructure and services.

In this context, I am pleased that the Ministry of Housing and Urban Poverty Alleviation and the United Nations Development Programme have prepared this useful guide for urban managers on reducing disaster risk reduction. This guide is particularly useful in light of the government's ambitious housing mission aimed at ensuring housing for all.

The Sendai Framework for DRR (2015-2030) notes that "addressing underlying disaster risk factors through disaster risk-informed public and private investments is more cost-effective than primary reliance on post-disaster response and recovery, and contributes to sustainable development". Therefore, there is an urgent need to mainstream disaster risk reduction into the urban development to strengthen resilience of infrastructure and communities to stresses and shocks from rapid urbanization, disasters and climate change.

Urban resilience can be strengthened only through the coordinated efforts of a range of stakeholders entrusted with developing our cities. The Handbook aims to empower urban managers to understand better key facets of disaster risk reduction towards risk-informed urban planning.

Jaco Cilliers
Country Director
UNDP India

preface

The increasing trend of disasters such as earthquakes, cyclones, landslides, flash floods and forest fires in India have exposed the vulnerability of the country's building stock, causing widespread damage resulting in loss of lives and property. The impact of disasters on cities is especially grave. The fundamental underlying causes are faulty design and construction practices which do not follow multi-hazard resistant features as per the building codes and standards. The capacities to make resilient cities need to be built at all levels, however, Urban Managers who play vital role in urban agenda are to be augmented with ready reckoner on Disaster Risk Reduction.

This 'Disaster Risk Reduction : A Handbook for Urban Managers' has been prepared with support from United Nations Development Programme (UNDP) and Building Materials & Technology Promotion Council (BMTPC) under the GOI-UNDP Project on Enhancing Institutional and Community Resilience to Disaster and Climate Change implemented by Ministry of Home Affairs.

The Handbook has been divided into 10 chapters:

- Chapter 1 introduces the handbook to the users.
- Chapter 2 gives a background and contextual information for risk sensitive urban planning.
- Chapter 3 explains the basic concepts of hazard, vulnerabilities, exposure and risks.
- Chapter 4 looks into the details of hazard risk vulnerability analysis (HRVA).
- Chapter 5 lays specific focus on risk sensitive planning measures and portraying key design considerations for increasing hazard resistance of houses.
- Chapter 6 describes the process for hazard proofing of buildings through rapid visual screening (RVS) for structural safety of buildings and retrofitting techniques for strengthening existing buildings to withstand multiple hazards.

- Chapter 7 outlines policies, plans and legislations related to risk sensitive planning of urban areas and legislative measures for making a city resilient through city specific legal instruments and other regulatory instruments.
- Chapter 8 presents the instruments for implementation and enforcement of techno-legal regime for disaster risk reduction and illustrates measures for ensuring compliance of building bye laws, land use and zoning regulations.
- Chapter 9 outlines role of urban managers for end-to-end management of urban areas in respect of disaster risk reduction.
- Chapter 10 concludes with recommendations for implementation of building codes and planning regulations.

Case studies have also been included to cite the good practices undertaken in risk sensitive urban planning.

I wish to put on record my sincere gratitude and deep appreciation towards Prof. Vinod Sharma, Vice Chairman, Sikkim Disaster Management Authority, Shri G.Padmanabhan, Shri Arun Sahdeo and Ms. Abha Mishra of UNDP, Shri Anshu Sharma, Shri Ajay Katuri, Shri Hari Kumar, Consultants, Shri Pankaj Gupta of BMTPC for writing different chapters of the book and bringing it to a presentable form. My special thanks to Shri Rajiv Ranjan Mishra, Joint Secretary (Housing), Ministry of Housing & Urban Poverty Alleviation, Government of India for overall guidance and stearing the writing of this Handbook. Dr. N.Chatterjee, Secretary, Ministry of Housing & Urban Poverty Alleviation, Government of India deserves special mention here for constant encouragement. I also acknowledge the efforts put by Shri Dalip Kumar of BMTPC and a team of designers at UNDP for layout and design of the book.

We hope that this Handbook serves as a handy tool for urban managers towards risk sensitive planning and ensuring safety and well-being of the citizens in the face of disasters.

Dr.Shailesh Kr.Agrawal
Executive Director
BMTPC

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1. Introduction

A large number of stakeholders are involved in planning and implementation of projects under the various developmental schemes launched by the Government of India. It is felt that while engineers, architects and other technical staff may have the desired knowledge and skill for integrating disaster risk reduction (DRR) and climate change adaptation (CCA), capacity of the urban managers will have to be strengthened to enable them to facilitate integration of DRR & CCA in planning and implementation of the projects under the different schemes. The development of a handbook for urban managers was therefore taken up to facilitate integration of DRR and CCA measures in construction activities undertaken in urban areas.

1.1 Objectives

The objective of developing a handbook for urban managers is to enable them to look critically and factor in DRR and CCA measures into each activity, that will be planned and executed, not only from the perspective of reducing the disaster vulnerability of that activity, but also from the perspective of minimizing that activity's potential contribution to hazard specific vulnerability.

1.2 Target Audience of the Handbook

The handbook is intended for urban managers including Mayer/MP/ chairperson/ Municipal Commissioners, Additional/Assistant Municipal Commissioners, Town Planners, departmental officers and other executives of municipal corporations/ councils/ municipalities. These managers have a role in formulating, approving and implementing various urban renewal schemes in their respective urban local bodies.

1.3 Development of the Handbook

The handbook has been developed by a team of consultants led by the Executive Director of Building Materials and Technology Promotion Council (BMTPC). The team was guided by an advisory committee under the chairmanship of the Joint Secretary (Housing), Ministry of Housing and Urban Poverty Alleviation (MoHUPA), Government of India. It comprised experts from MoHUPA, United Nations Development Programme (UNDP) and Indian Institute of Public Administration (IIPA). Experts and practitioners from the states and academic institutions were involved in the consultation process at various stages of the handbook preparation.

1.4 Using the Handbook

The handbook is a useful resource for making our cities safer from disaster and climate change related risks. It will serve as a ready reckoner for those working in the areas of urban planning, urban development and urban management across development authorities, municipal bodies and technical support groups.

It has been prepared with simple description and a series of illustrations to make the concepts clear and easy to understand. Reference material and links have been provided for further details on any particular aspect.

The handbook may be used as a reference document specifically for integrating disaster risk reduction within urban planning, and also as an orientation document for staff involved.

It is highly recommended to make this an essential reading for all those who are involved in construction activities in particular planning, development and management of our cities. The growth of the housing sector will benefit from this resource, and we will be able to make new as well as existing buildings safer from all kinds of hazards by using this resource and building our knowledge base on how to anticipate and mitigate these risks.

1.5 Way Forward

The handbook is a step towards the long term goal of eliminating loss of life and property due to disasters in cities and covers some of the critical initial stages related to assessments, planning and ensuring building safety. Much needs to be done beyond this though, including focus on green and sustainable buildings; shift from non-renewable to renewable sources of energy; water conservation; reuse and recycling; outdoor and indoor air pollution control; and reduction of heat island effect, among other things.

The process may be seen as one of reducing the impact of shocks (high impact low probability events such as earthquakes, cyclones and floods), and stresses (low impact high probability events such as water stress, heat and pollution). Starting with intense impact events, the process of risk reduction must expand to cover all existing and anticipated risks to cities, which will be covered by Government of India and its partners under its ongoing programmes. Urban managers will play a critical role in implementing these concepts to ensure safer urban spaces in India.

2. Background

With a rapidly growing economy, India has experienced exponential urban growth in the last few decades. The urban population has grown from 285 million in 2001 to 377 million in 2011, and is likely to touch 533 million by 2025. To address the increasing demand for houses in urban India, the Government of India has approved a "Housing for All by 2022" initiative for urban areas, which aims to provide two crore affordable homes to the homeless, urban poor and people belonging to economically weaker sections and lower income groups, in the next seven years. Housing policy in India which earlier focused on building houses has substantially shifted to creating an enabling framework, improving access to credit and encouraging multi-stakeholder participation in housing. These policies also focus on sustainability, social inclusion with single window clearance, modified building Codes and byelaws and now incorporate provisions for 'green buildings', natural disaster resilience and inclusive design for the elderly and the differently abled.

The mission operates through four verticals for States/Union Territories and cities:

a) Rehabilitation of slum dwellers with participation of private developers using land as a resource;
b) Promotion of affordable housing for weaker section through credit linked subsidy;
c) Affordable housing in partnership with public and private sectors; and
d) Subsidy for beneficiary-led individual house construction or enhancement.

A Technology Sub-Mission under the "Housing for All" Mission has been set up to facilitate adoption of modern, innovative and green technologies and building materials for faster and quality construction of houses. The Technology Sub-Mission will facilitate preparation and adoption of layout designs and building plans suitable for various geo-climatic zones. It will also assist States/Cities in deploying disaster resistant and environment friendly technologies.

Recognizing that development and resilience are unlikely to be sustained unless disaster risk is explicitly addressed in all development initiatives, Government of India has been striving to integrate DRR in development planning of key sectors, such as housing, rural development, urban development, education, agriculture, environment and health. The Ministry of Home Affairs (Government of India), with the support of UNDP, carried out a review of 13 national flagship programmes on integration of DRR and CCA features. The study suggests that the process of mainstreaming DRR into development planning is impeded due to

lack of guidelines, appropriate tools and methodologies. The study recommends that appropriate policy & planning interventions supported by guidelines, tools, methodologies, adequate financial allocation and capacity building of all stakeholders would be required for mainstreaming DRR & CCA in various sectoral schemes.

2.1 Status of Urban Housing in India

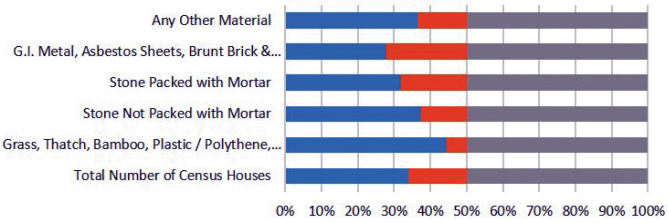
In 2008, the Ministry of Housing and Poverty Alleviation (Government of India) constituted a high level task force to look into the various aspects of providing affordable housing for all. As per the task force, many of the development plans created in the last decades have not considered the implications of hazardous conditions within the cities.

Current housing conditions across agro-climatic regions have been facing the impact of climate change; the building materials used to construct the houses render them unliveable. E.g., houses in Himachal Pradesh are traditionally made without provision for fans or air conditioners. However, with the changing meteorological conditions, people in the state are experiencing discomfort due to increasing temperatures indoors, and thus, are opting for fans and air conditioners. Changing geophysical and hydro-meteorological conditions, fire and impact of extreme heat/heatwave condition indirectly affect thermal comfort within buildings.

Also, much of the housing stock in India is of non-engineered buildings. It has been observed that more than 60% of the existing housing stock in some cities is vulnerable to earthquakes, landslides and other hazards or high impact events.

As shown in Table 1, about 12 percent of the houses within urban areas use temporary building materials like grass, thatch, bamboo, plastic/polythene, mud, unburnt brick and wood (Census 2011). About 30 percent of the urban houses in India are at zero plinth level, which means they are exposed to frequent inundation/water logging problems. In urban areas, almost 40 percent of the households live in multi-storied apartments, which might not have any form of building checks while being constructed (National Sample Survey Office, 2014). Around 3 percent of the housing stock is classified as 'dilapidated' (Census 2011). This dilapidated housing stock holds about 22.7 lakh households, i.e. approximately 113.5 lakh people, who also do not have access to essential services like clean water supply and sanitation facilities. Around 23.1 lakh households, amounting to 1,156 lakh people, do not have safe drinking water.

Figure 1: Distribution of Census Houses by Predominant Material of Wall (in million)



	Total Number of Census Houses	Grass, Thatch, Bamboo, Plastic / Polythene, Mud, Unburnt Brick & Wood	Stone Not Packed with Mortar	Stone Packed with Mortar	G.I. Metal, Asbestos Sheets, Brunt Brick & Concrete	Any Other Material
Rural	206.56	87.64	7.75	20.93	88.59	1.65
Urban	98.32	11.64	2.69	12.11	71.27	0.61
India	304.88	99.28	10.44	33.04	159.86	2.26

Source: Census of India, 2011

Given the circumstances, not only are the buildings vulnerable to disasters, the residents too will be rendered without any basic amenities, if they survive the events. The Handbook for urban managers aims to provide technical support to policy/decision makers on the issues of hazards, risks, vulnerabilities and capacities.

3. Basic Concepts of Disaster Management

The concept of 'risk' combines an understanding of the likelihood of a hazardous event occurring with an assessment of its impact. The risk of disaster is a compound function of the natural hazard and the number of people, characterised by their varying degrees of vulnerability to that specific hazard, who occupy the space and time of exposure to the hazard event. A disaster occurs when a significant number of vulnerable people experience a hazard and suffer severe damage and/or disruption of their livelihood system in such a way that recovery is unlikely without external aid.

Risk is generally defined as the combination of the probability of an event and its negative consequences. Risk is, thus, the probability that the occurrence of a hazard will result in disaster. E.g. an earthquake striking a community where all buildings are earthquake resistant and the community is fully prepared for it does not result in a disaster. Thus, the earthquake risk at a place is dependent on the vulnerability of the building stock and the coping capacities of the community.

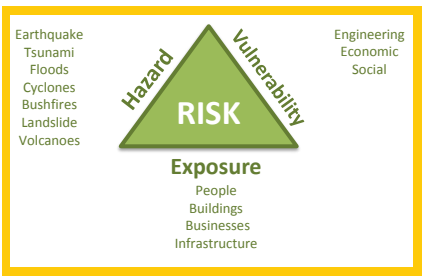
High hazard and vulnerability aggravate the risk at a place while high community capacities reduce the risk. An oversimplified way of projecting the interdependencies of these factors and the risk at a place is:

Hazard X Vulnerability/Capacity = Risk at a place

Thus, the reduction or mitigation of risk involves the reduction in the vulnerability and an increase of capacities within the community.

While awareness and capacity building are other necessary initiatives that will have to be taken up at the community level, this Handbook focuses on the efforts required for components of structural vulnerability reduction. In case of new development, this will include measures such as a robust techno-legal regime, enforcement mechanisms etc. to ensure that all future constructions are earthquake resistant.

Hazardous events can be either naturally occurring such as earthquakes, floods, cyclones or human-made such as water pollution or terrorist attack. In addition, such events can be sudden as in the case of an earthquake, or they can occur over time as in the case for most environmental hazards. The impact of a



Box 1

United Nations Office for Disaster Risk Reduction (UNISDR) Terminology

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.

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

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

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

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.

hazardous event depends on the elements at risk, such as population or buildings and their associated vulnerability to damage or change as a result of the event. The total risk may be decreased by reducing the size of any one or more of the three contributing variables: the hazard, the elements exposed and/or their vulnerability. This can be illustrated by assuming the dimension of each of the three variables represents the side of a triangle, with risk represented by the area of the triangle. The reduction of any one of the three factors to zero consequently would eliminate the risk.

In the case of urban India, existing vulnerable housing stock has to be addressed through retrofitting taken up by the community as a long term mitigation measure. However, due to the sheer number of vulnerable buildings in the country, we have to prioritise our interventions based on the importance of a building's functions and also by understanding the broad quantity and quality of its vulnerability through rapid visual screening (RVS) of the building stock.

3.1 Concepts of Hazard, Risk, Vulnerability and Capacity

3.1.1 Hazards

Geological hazards: Earthquakes, landslides and avalanches are examples of geological hazards caused due to geologic processes of the earth. An earthquake is the shaking of the surface of the earth as a result of seismic waves, and can trigger landslides and avalanches, depending on soil conditions. Data sets needed for understanding these hazards are geology, lithology, faults and lineaments, soil profile, level of water table, etc. However, tsunamis triggered

by earthquakes in the middle of the ocean/sea are hard to model and observe.

Hydro-meteorological hazards: Cyclones, floods, droughts, hailstorms, cloudbursts, heat and cold waves, etc. are hydro-meteorological hazards caused by prevalent hydrological and meteorological conditions. In order to understand and quantify the effects of these hazards, we need weather-related data along with data of the ground conditions. Data for understanding the cyclones are usually collected at the country level, in India by the India Meteorological Department (IMD). Other data sets which may be compiled for monitoring the hydro-meteorological hazards are rainfall, temperature, runoff conditions, land use land cover, natural drainage and topography, etc.

Fires (forest fires and urban fires): During the hot periods of the year, dried up leaves and twigs in forest areas catch fire and lead to catastrophe. Additionally, typically after harvesting, crops are burnt to dispose off crop stubble/residue in rural areas. Urban fire data can be obtained from urban fire calls from the fire departments and can be spatially mapped and used for decision making. Forest fires are monitored worldwide through satellites. MODIS (available at http://modis-fire.umd.edu/index.php) provides global level data at 1 km scale.

Anthropogenic hazards: To understand industrial hazards and their extent, it is important to have knowledge on types of chemicals stored in the facility as well as the state and quantum of the chemical that has led to the hazard. Based on the chemical properties and the weather conditions, simulations can be run to ascertain the extent of the disruption.

3.1.2 Risk

The term 'risk' refers to the expected losses from a given hazard to a given element at risk over a specified future time period. According to the way in which the element at risk is defined, the risk may be measured in terms of expected economic loss or in terms of numbers of lives lost or the extent of physical damage to property. The overall task of risk management must include both an estimation of the magnitude of a particular risk and an evaluation of how important the risk is.

3.1.3 Vulnerability

Population vulnerability: The number of people susceptible to an event is defined as population vulnerability and is further classified as intrinsic and extrinsic vulnerability. Intrinsic vulnerability is based on the attributes of the population (e.g. fragile age group, social status in the society, access to resources, etc.) while

extrinsic vulnerability is lack of capacity to resist the influence (often negative) from external processes (inundation during flood, loss of economic activities because of earthquake, etc.).

Building vulnerability: The vulnerability of buildings is assessed through RVS. In a non-homogeneous building stock, detailed testing is required to understand the structural strength – compressive and tensile. The parameters that can define a building's vulnerability are position and details of columns and beams; presence of horizontal bands; load design of the building; configuration of the building; height of the building; age of the building; quality of construction; etc.

Economic vulnerability: It is important to have information on economic activities that could be affected by the hazards innate to an area. The extent of disruption to these activities in case a hazard manifests itself as a disaster is an indicator of the economic vulnerability. For example, in case of a tourist destination, the decrease in tourist arrival observed after a hazardous event is broadly termed as economic vulnerability. The number of man-days lost and opportunity cost of the business lost are to be calculated to assess the economic vulnerability.

3.1.4 Capacity

Very often capacity is used to define the resilience of society.

Capacity at household level: A household's level of preparedness in the eventuality of a disaster determines its capacity. If the resources available to the household can sustain till external aid arrives, then the household's capacity can be termed as good. Capacity also includes the level of awareness regarding disasters. Data needed to assess the capacity at the household level is the number of households in the given area that are self-reliant and aware of their capacity.

Capacity at community level: If a community has adequate provisions for storage of water, food, fuel, medicines and other resources and can sustain its daily activities till external aid reaches, that community can be termed as a resilient community (or a community with capacity). Community capacity can be assessed based on the community resources; awareness (not just literacy) of people within the community; transmission of early warning messages; access to health facilities; proximity to transport networks etc.

Capacity at local body level: Awareness of a local body about the hazards, vulnerabilities and risks faced by the settlement (either city or town) is the key to understanding the capacity of the local body. Capacity of the local body can be

assessed by number of officials trained in DRR related activities; existing disaster management plans for the city; building stock analysis; population vulnerability; transport networks; open spaces for assembly and resettlement purposes; effectiveness of the fire service; reach of hospital and medical facilities; places of high density; infrastructure service level etc.

3.1.5 Prevention

Prevention is defined as those activities taken to prevent a natural phenomenon or potential hazard from having harmful effects on either people or economic assets. Prevention planning is based on two issues: hazard identification (identifying the actual threats facing a community) and vulnerability assessment (evaluating the risk and capacity of a community to handle the consequences of the disaster). Once these issues put in order of priority, urban managers can determine the appropriate prevention strategies. Disaster prevention refers to measures taken to eliminate the root causes that make people vulnerable to disaster.

3.1.6 Mitigation

Mitigation refers to reducing the resistance of the hazard and reducing vulnerability. Mitigation includes recognizing that disasters will occur; attempts are made to reduce the harmful effects of a disaster, and to limit their impact on human suffering and economic assets.

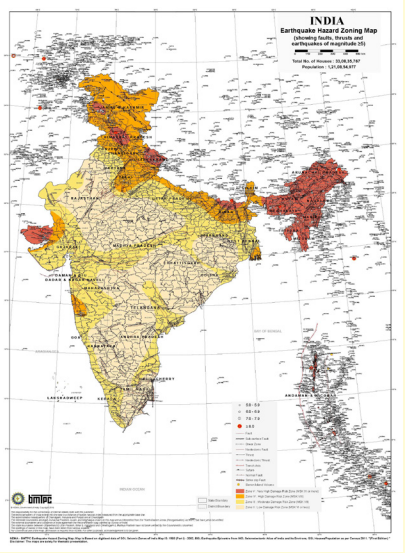
3.2 Risk Sensitive Planning

Risk sensitive planning looks into reinforcing physical planning exercises through the lens of resilience building. It includes mainstreaming disaster risk management processes in spatial development plans. This process involves identification of area-specific hazards, risks, vulnerability and capacity of people and correlating the risk information in the development planning process. Based on this information, spatial planning measures sensitive to addressing identified risks are decided in consensus with key stakeholders and the zoning regulations of the area.

3.3 Hazard Profile of India

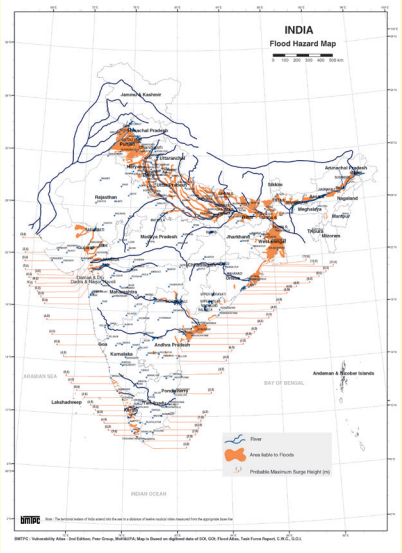
India is spread across a vast land area with varying physiographic and meteorological features. Due to this diversity, India experiences multiple natural hazards. The list of prevalent natural hazards include earthquake, flood, drought, landslide and avalanche, cyclone, tsunami, flash flood, heat waves, cold waves, etc. India is also vulnerable to man-made hazards like chemical, biological,

Figure 2: Seismic Hazard Map of India



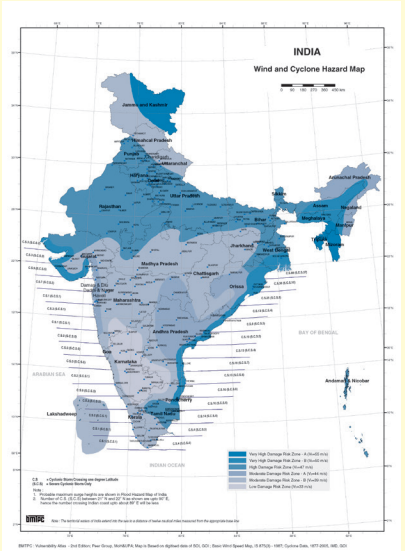
Source: NDMA-BMTPC Earthquake Hazard Zoning Atlas, 2016

Figure 3: Flood Hazard Map of India



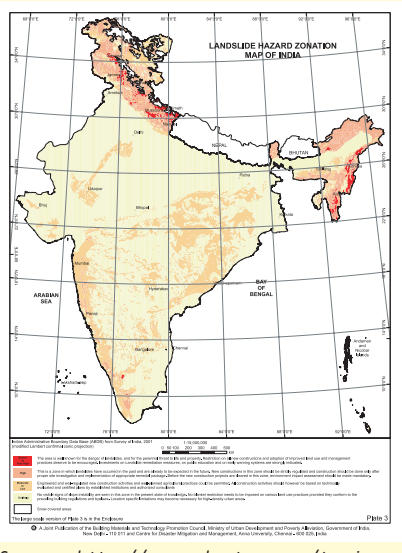
Source:http://www.bmtpc.org/DataFiles/CMS/file/map%20of%20india/flood.pdf

Figure 4: Wind and Cyclone Hazard Map of India



Source:http://www.bmtpc.org/DataFiles/CMS/file/map%20of%20india/wind-india.pdf

Figure 5: Landslide Hazard Map of India



Source:http://www.bmtpc.org/topics.aspx?mid=56&Mid1=186

radiological and nuclear threats. The risks of disasters are compounded further due to increasing population, unplanned urbanisation, damage to environment, geological hazards, epidemics, etc.

Building Materials & Technology Promotion Council (BMTPC) has prepared Vulnerability Atlas of India which gives hazard maps with respect to earthquakes (Figure 2), floods (Figure 3), wind and cyclones (Figure 4) and landslides (Figure 5) in the country. The following maps presents the hazard maps prepared by BMTPC:

4. Hazard Risk Vulnerability Analysis

Hazard Risk Vulnerability Analysis (HRVA) is a highly technical process typically undertaken by specialist professionals with advanced educational qualifications and vast field experience. However, effort has been made to simplify the process, so that even a generalist administrator can acquire requisite knowledge and skills to carry out HRVA activities.

4.1 Understanding HRVA

To mitigate disaster-related risks, it is essential to understand the relationship between hazards and vulnerabilities in any given area. Typically, local authorities are busy with their regular routine, not leaving much scope for a HRVA to be carried out. Some of the advantages of carrying out HRVA include:

- Communities can develop effective warning and evacuation systems
- Community planning initiatives can factor in potential risks to housing stock and economic activities
- Equipped with an understanding of a community's vulnerability to a particular hazard, mitigation projects can reduce the risk of a disaster and its consequences
- Well-informed communities are well-prepared communities and can collectively work towards preventing potential disaster-induced losses

However, it is also important to remember that planning for hazards that are unlikely to occur and hazards that will have little impact could be a waste of time and resources.

4.2 How to apply the HRVA to an Indian city

Conducting HRVA of a city, involves the following steps:

1. **Preparation of hazard and exposure database:** A detailed database of existing hazards can be prepared using historical data. The District Gazetteer can be a good place to gather this data from.

2. **Mapping vulnerable population:** Using available manpower within the city/town, spatial mapping of the vulnerable population can be done. Localities where marginalised groups, differently abled and women-headed households live can be identified, which will help in effectively carrying out emergency response activities. Similarly, spatial location of illiterate people ,and areas with a high concentration of children (< 6 yrs)/elderly (> 60 yrs) will be useful.

3. **Understanding building vulnerability:** Basic understanding of the building topology within the city and its characteristics is an important step. All the buildings within a given city can be classified into common groups viz. reinforced

concrete buildings, stone/brick load bearing buildings, wooden buildings, buildings made of temporary materials (like plastic, bamboo, cloth, etc.). Based on the construction techniques used within the city or state, the strength of these buildings can be assessed without much technical capability. Pockets of areas which have sub-standard or weaker buildings need to be identified and remedial measures need to be planned.

4. Exposure database: Once the hazard database and the vulnerability database is ready, the decision maker can overlay the two datasets (hazard database and vulnerability datasets – population and buildings, separately) to get zones of exposure.

5. Risk Assessment: Understanding which elements at risk are exposed to which type of hazard, repetitiveness of that hazard (frequency or return period), possible intensity in the given city, etc. will give more clues about the possible risk posed in the city. Wherever higher vulnerable population overlaps higher intensity hazard, the resultant risk will be higher.

6. Risk reduction measures: Based on the hazards, vulnerabilities and resulting risks, the city manager can make decisions on how to reduce the risks. Local expertise and understanding of elements at risk will help in prioritising these risk reduction measures. Literature on risk reduction measures can be sourced from the World Bank, UNISDR, Asian Disaster Preparedness Center (ADPC), Prevention Web, and other websites. However, care should be taken that these measures are localised based on the characteristics of the population.

4.3 Data Requirements for Conducting HRVA at City level

Conducting HRVA is a data intensive process and many of our urban areas do not have the data for the same. Every city needs a base map with different thematic layers, such as geology, topology, lithology, land use land cover, natural drainage, transport networks, emergency lifelines systems, piped/conduit based services, telecommunications, etc. The data needs for a HRVA can be broadly divided into three sets: Hazard, Vulnerability and Capacity data sets. A detailed set of attributes for the three themes will be an added benefit. To gauge the vulnerability of population, buildings and economic activities, we need to have a detailed housing stock inventory, demographic details and an inventory of the economic activities the population is engaged with.

4.4 Approach and Methodologies for Conducting HRVA at Various Levels

HRVA can be conducted at various levels viz., ward, city, agglomeration; metropolitan; district and state. In smaller countries, HRVA is conducted at the

national level. Though the levels are different, the process of conducting the HRVA is more or less similar. Assessment of individual components of hazards, vulnerabilities and risks is to be carried out at all levels. Based on the capacity analysis, recommendations can be made.

HRVA can assist local authorities in investment prioritisation. However, it is just the first step toward the preparation of a city level decision support system (DSS).

4.5 Technical Agencies in India for HRVA

There are not many institutions that have the capacity to carry out HRVA analysis in India, since the process requires a multi-disciplinary approach and highly trained man power. A list of agencies in the country that provide HRVA services is given in Table 1.

Table 1: List of Agencies Provide HRVA Services

Agency	Expertise for assessment
India Meteorological Department (IMD)	Forecast meteorological information for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc. Warn against severe weather phenomena like tropical cyclones, dust storms, heavy rains and snow, cold and heat waves, etc. Detect and locate earthquakes and to evaluate seismicity in different parts of the country for development projects.
Geological Survey of India (GSI)	Prepare landslide hazard zonation Prepare seismic microzonation for various cities
Central Water Commission (CWC)	Monitor the surface water bodies in the country along with the dam sites Real time water quality Flood forecasting Surface water information system
Building Materials & Technology Promotion Council (BMTPC)	Incentivises entrepreneurs in setting up manufacturing units Created first vulnerability atlas of the country Carry out research in the areas of habitat
National Remote Sensing Agency (NRSA)	Provides satellite based hazard maps Works suo-moto based on the need of the hour Through Bhuvan, disseminates the hazard information overlaid with administrative boundaries
TARU	Have been working on multi-hazard risk assessment. Created first vulnerability atlas of the country, in Gujarat.
RMSI	Risk Management Solutions, India. Provides comprehensive multi-hazard risk assessment Worked in many parts of country so far on similar assignments
SEEDS	Sustainable Environment and Ecological Development Society (SEEDS) Assessment carried out for HRVA including training needs assessment. Experience of carrying out projects from local, city, block, district, state, national to international level.

HRVA can assist the local authority in making investment prioritisation. However, it is the first step for the preparation of a city level decision support system (DSS).

Steps to undertake Hazard Risk and Vulnerability Analysis

Identify hazards using scientific study and historical database

Do the spatial mapping of the vulnerable population

Assess the infrastructure/assets
Identify the weak buildings

Ascertain the probability of intensity and frequency of different hazards

Prioritise risk reduction measures based on the understanding of the risk

Data requirements for carrying out HRVA at a city level

City needs a BASE MAP with different thematic layers

Geology

Topology

Lithology

Landuse/Land-cover

Natural Drainage

Transport network

Emergency Life-line system

Piped conduit based service

Telecom

Categorise the data into three sets

Hazard dataset

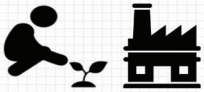
Vulnerability dataset

Capacity dataset

Understand the vulnerability of population, buildings and economic activities

Detailed building stock inventory

Demographic details



Inventory of economic activities

In a nutshell:

$$\text{Disater risks} = \frac{(\text{Hazard} \times \text{Vulnerability}) \times \text{Exposure}}{\text{Capacity}}$$

5. Risk Sensitive Planning

5.1 Key Considerations

Risk sensitive urban planning involves mainstreaming disaster risk management within the governance and operations of public and private institutions, particularly in spatial and physical development plans. It incorporates disaster risk management through institutional and legal reforms, plans, programmes and projects that dictate land use, land management, and infrastructure development. For planning institutions which are only familiar with traditional planning, the main difficulty is in how to use disaster risk information in determining its implications to development and spatial plans.

Various types and scales of urban plans, from territorial to land-use zoning, can help to protect environmentally sensitive areas, reduce vulnerability and disaster risk, mitigate climate change and increase resilience. However, to be effective, risk-sensitive urban planning and development process should consider multiple steps from data collection to plan design and its implementation over a sustainable time period.

5.2 Risk Sensitive Urban Planning

5.2.1 Basic steps for risk sensitive urban planning

The basic steps for risk sensitive urban planning are as follows:

1. Comprehensive assessment of hazards, risks, vulnerability and capacity
2. Application of planning laws and regulation for addressing risks
3. Development of base maps to mark risk areas
4. Participatory discussions to analyse local context
5. Revision of existing development plans
6. Formulation of projects that include risk sensitive component
7. Public awareness for increased knowledge base
8. Capacity building for planning as well as implementation
9. Focus on children, women, elderly and differently abled persons' needs
10. Addressing budget requirements for risk sensitive planning

Box 2

Case: Transformation of Surat – From Plague to Second Cleanest City in India

Picture: Pablo Bartholomew/Netphotograph

Surat suffered an outbreak of bubonic plague in 1994. The plague claimed 56 lives and many citizens fled the city. Surat's narrow streets, dense settlements and poor drainage systems made cleansing the city and preventing the further spread of disease a significant challenge.

The Surat local authority and the municipal commissioner at the time ensured that major roads and markets were cleaned twice a day; enforced strict hygiene and sanitation standards in eating houses, sweetshops, fruit and vegetable shops; fined people for littering; improved solid waste management; and divided the city into 52 sanitary wards, each of which had its own cleanliness inspector. The city also launched public-private partnerships to improve waste collection.

This transformation was largely due to improved municipal management, which was brought about by a strong leadership. Its initial success led to widespread support among the local population and provided motivation for the municipal staff and the elected representatives to make further improvements in the city. The Surat experience has demonstrated that urban local governments in the developing countries have the capacity to face the challenges of rapid urbanisation and improve the quality of life of all the residents.

Results were visible within weeks, and today, Surat is seen as one of India's cleanest cities. Surat also built upon its early successes. It has set an example with its computerised water distribution and drainage system and modern sewage treatment plants. Surat's policies and solutions have become a national model for other cities to follow.

Source: Transformation of Surat, AIILSG, New Delhi.
Weblink: http://www.indiawaterportal.org/sites/indiawaterportal.org/files/UI_1-Surat.pdf

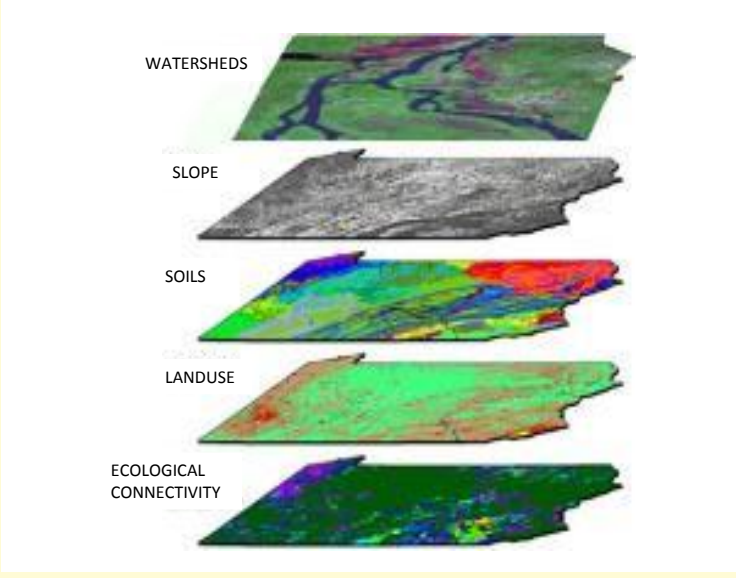
Upgrading Sanitation standards to improve health, India Smart Cities Challenge.
Weblink: http://www.smartcitieschallenge.in/casestudy/surat-upgrading- sanitation-standards-to-improve-public-health

5.2.2 Environmental planning

Environmental principles need to govern the development pattern, location of critical land-uses, and concentration of populations. Care needs to be taken to:

- Identify natural features such as drainage channels and water bodies that need to be protected
- Identify high risk zones where population and investment concentration is to be avoided

Figure 6: Multi theme analysis to ensure land suitability



Source: geospatialworld.net.

- Use suitability analysis to match best land parcels for specific uses
- Identify carrying capacity of natural and built systems, and plan populations and activities accordingly
- Use participatory assessment and planning for multi layered GIS analysis across themes

5.2.3 Improving the preparedness of cities to respond to shocks and stresses

A city needs to be prepared to face hazards that are inevitable despite best efforts

in disaster mitigation. Ensure the preparedness of your city for the following factors through awareness, training, planning and equipping of general public as well as responsible agencies:

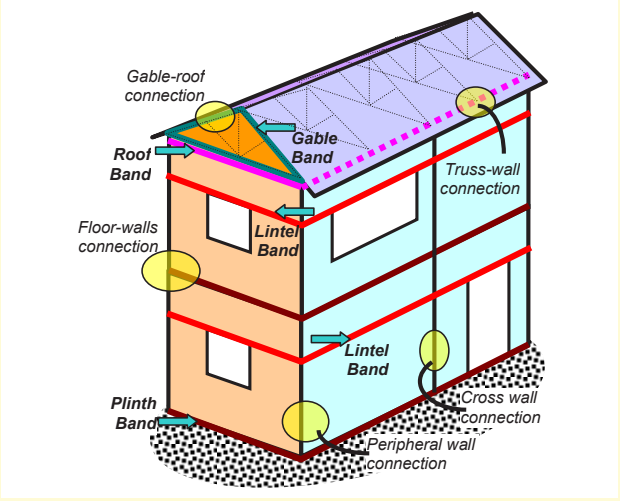
- Shocks: Rapid onset disasters with low probability but high impact. Example: Earthquakes.
- Stresses: Slow onset disasters with high probability yet low impact. Example: Water stress or water logging, leading to disease.

5.2.4 Designing safer and greener buildings

Safety and sustainability needs to be ensured in buildings made of varying materials, catering to different income groups and functions. Towards this:

- Create a building inventory of the city, and keep it updated in real time

Figure 7: Horizontal bands in masonry building



Source: IITK-BMTPC Earthquake Tips - Earthquake Design and Construction by C.V.R. Murthy, IIT Kanpur http://www.ultrabricks.com/restudy14.htm

- Publicise in simple terms the key aspects of safe construction for new buildings, and maintaining and retrofitting for existing ones
- Strengthen training, certification and monitoring of architects, engineers, construction contractors, and masons

- Identify low income areas with non-engineered buildings, and apply Mandatory Rules of Thumb
- Encourage green buildings with water harvesting, solar-passive design, solar photovoltaic energy, waste management and landscaping.

5.2.5 Designing safer infrastructure

Infrastructure is one of the key elements for the smooth operation and survival of a city. The infrastructure itself needs to be safe for citizens and must be resilient to disasters. The following considerations may be useful:

- **Physical Infrastructure:** Ensure that the design of housing, roads, airports, ports, electricity network, sewerage, water supply, public and commercial buildings, and public utilities are assessed for their exposure to disaster risks due to their location, quality of construction and maintenance. Follow up with risk reduction measures through planning and retrofitting.
- **Social Infrastructure:** Ensure that the schools, health facilities, and community spaces are assessed for their risk exposure, and appropriate mitigation and preparedness plans are put in place.
- **Economic and Institutional Infrastructure:** Banks, financial institutions, administrative establishments and emergency services are lifelines for the city, and need to be assessed for risk and their safety ensured through planning and retrofitting interventions.

5.3 Hazard Resistance in Buildings

The behaviour of a building during any disaster depends critically on its location, overall shape, size and geometry. Hence, at the planning stage, architects and structural engineers must work together to ensure that the unfavourable features are avoided and a good building configuration is chosen.

5.3.1 Considerations for appropriate siting for structures

For safe site selection, the following broad points should be kept in mind:

- Safe site which is away from landslides, steep slopes, falling rocks, loose soil and polluted water
- Well-drained area to avoid risk of water-logging and vector borne diseases.

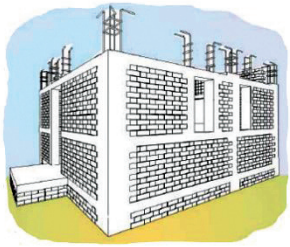
Inappropriate site selections:

5.3.2 Model designs and application of hazard resistance in construction

The basic design consideration for increasing hazard resistance of houses should include the following:

Earthquake[1]

- Frame, or bands at different places (plinth, lintel and roof)
- Shear walls
- Cross bracing
- Base isolation (shock absorption)
- Brick joinery



Flood

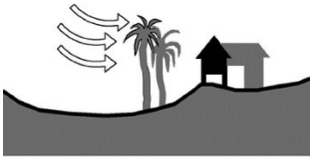
- Raised plinth / building on stilts
- Strong plinth
- Water proofing of houses

Cyclone

- Suitable location to minimize wind force
- Roof tied to walls
- Firm fixing of building components together (foundations, walls, roof structure and roof covering)
- Improved aerodynamics of the structure
- Long root bearing plant trees as wind breakers

Landslide

- Proper site selection
- Design of retaining walls



Shielding from high wind by permeable barriers such as strong trees

5.4 Multi-Stakeholder Engagement

DRR is not a department specific concern; it is everyone's business. A collective decision making process is required to ensure incorporation of views of all the concerned stakeholders, which can be achieved through multi-stakeholder engagement. The process takes into account that all sections of society with relevant knowledge and experience come together to decide upon issues related to DRR and find solutions accepted by all. This is a people centric approach and each stakeholder involved has a responsibility for the outcome. The

[1] *HUDCO's Role and Contribution in Disaster Preparedness and Mitigation. Weblink:http://cidbimena.desastres.hn/docum/crid/Jun-Jul2004/pdf/eng/doc15224/doc15224-contenido.pdf*

Box 3

Indian Standards/Codes Relating to Structural Safety from Natural Hazards

For Protection from Cyclone/Wind Storm

1. IS 875 (3)-1987 "Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures, Part 3, Wind Loads" (Second Revision)
2. IS 15498 Guidelines for improving the Cyclonic Resistance of Low rise houses and other buildings

For Protection from Earthquake

3. IS: 1893-2002 "Criteria for Earthquake Resistant Design of Structures (Fifth Revision)"
4. IS: 4326-1993 "Earthquake Resistant Design and Construction of Buildings- Code of Practice (Second Revision)"
5. IS: 13828-1993 "Improving Earthquake Resistance of Low Strength Masonry Buildings- Guidelines"
6. IS: 13827-1993 "Improving Earthquake Resistance of Earthen Buildings - Guidelines",
7. IS: 13920-1993 "Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces- Code of Practice"
8. IS: 13935-1993 "Repair and Seismic Strengthening of Buildings- Guidelines"

For Protection from Landslide Hazard

9. IS 14458 (Part 1): 1998 Guidelines for retaining wall for hill area: Part 1 Selection of type of wall.

process increases the ownership of the decisions, thereby making it easy for implementation and acceptance by the society.

For risk sensitive planning, various stakeholders should be engaged to identify milestones and key criteria for enhancing the effectiveness and sustainability of disaster risk measures. These should then be integrated in the spatial development plans of the area.

5.5 Role of technology

Today, the role of technology is evident in managing emergency situations and disaster risks and events as well as substantial reduction of losses during a disaster. The enhanced warning systems, live monitoring of activities, database, use of satellites for remote sensing, GIS (Geographic Information System), GPS (Global Positioning System), social media, etc. have taken the conventional techniques of disaster risk reduction to a new level. Use of such technologies should be promoted in the decision making and planning process.

10 Step Risk Sensitive Urban Planning

RISK SENSITIVE URBAN PLANNING

involves mainstreaming Disaster Risk Management (DRM) within the governance and operations of public and private institutions particularly in spatial and physical development plans

The key steps for RISK SENSITIVE URBAN PLANNING

1 Comprehensive Assessment of hazards, risks, vulnerability and capacity

2 Application of planning laws and regulation for addressing risks

Laws & Regulations

Policies, laws and regulations provide the foundation upon which strategies can be built to integrate risk reduction into development practice

Effective Governance

Participation, transparency, accountability, efficiency and responsiveness are some of the principles of good governance

Strict Enforcement

Laws & regulations must be strictly enforced to mitigate the impact of natural hazards

Adherence to the laws

Adherence to the laws must be made mandatory as that will build a strong foundation and ensure sustainable development

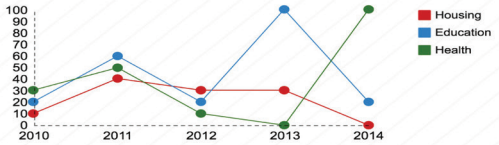
Legal compliance

Ensure strict compliance of technical and legal provisions of codes, bye-laws and regulations

3 Development of base maps to mark risk areas

4. Participatory approach to address local concerns
5. Revision of existing development plans
6. Formulation of project that incorporate risk sensitive component
7. Public awareness for increased knowledge base
8. Capacity building for planning as well as implementation
9. Focus on children, women, elderly and differently abled persons' needs

10 Addressing budget requirements for risk sensitive planning



Analyzing the historical data will help you assess the key budget requirements for each sector. This will help you and your team to make strategic plan and allocate budget accordingly.

6. Hazard Proofing of Buildings: Rapid Visual Screening and Retrofitting Techniques

6.1 Rapid Visual Screening

Figure 8: RVS is for assessing large sets of buildings in a locality

Across the world, there are several methodologies for conducting seismic safety evaluation of buildings. Most of these methods follow a three level assessment procedure involving:

1. Rapid Visual Screening (RVS) of Buildings (or Tier 1 Evaluation)
2. Preliminary Assessment (or Tier 2 Evaluation)
3. Detailed Evaluation (or Tier 3 Evaluation)

RVS methods range from activities requiring about 20 minutes to more detailed ones involving basic calculations.

Figure 9: Engineer carrying out RVS of a building

RVS is a basic methodology to assess a large stock of buildings in a town or city only by observing the building and walking around it, and recording features that determine how the building will likely behave during an earthquake. RVS does not require detailed analysis and is suitable for very large samples of building stock as it involves side-walk survey either without entering the building or doing so for a short duration only (20-25 minutes).

RVS can be very valuable to prioritise the buildings to be further studied so that technical and other resources could be most effectively utilised. While it sounds like a fairly simple exercise, it should be done only by trained personnel with a background in civil engineering or architecture. This is so because the method requires use of technical judgement that can be acquired only through formal training. RVS should not be done by lay persons as this could lead to misleading conclusions.

Typically, RVS involves filling up standard forms where the surveyor notes the location of the building being surveyed in the seismic zone, prepares a simple line drawing of the building plan and notes the presence or absence of earthquake resistant features (by ticking appropriate boxes) in the form.

6.1.1 RVS methodology- Masonry Buildings

The two most prevalent types of buildings in municipalities of India are masonry or load bearing buildings and reinforced concrete frame buildings. Hence, for carrying out a RVS level of assessment in any municipality, there are two standardized formats, one each for the two most common types of buildings prevalent in the country.

Masonry buildings are very common in India and account for about 75 percent of the houses in the country. These are usually buildings where the brick walls carry the load and transfer the weight to the foundation. In most cases, these buildings have a roof and floors made of reinforced cement concrete slabs. These types of buildings are usually not more than three storeys in height. The walls may be made of different types of masonry units such as mud bricks, fly ash bricks, concrete blocks, dressed rubble, coarse rubble etc.

In India, RVS of masonry buildings is carried out as per the Bureau of Indian Standards format in the code document IS13935:2009 (Seismic Evaluation,

Figure 10: A masonry building

Repair and Strengthening of Masonry Buildings – Guidelines), provided in Annexure A. This code has a number of formats for conducting RVS on masonry buildings with a different format for each seismic zone of India.

The code also classifies buildings as ordinary and important. Important buildings are those that have critical functions and need to be functional after earthquakes, such as hospitals, emergency operation centres etc. The code recommends that any building with over 100 occupants should be considered as 'Important'.

6.2 Retrofitting

Retrofitting is several steps beyond repair and rehabilitation of buildings. Repair of a building is the process of repairing the damages to a building due to normal wear and tear or a natural hazard to try and bring the building as close to its original strength as possible.

Figure 11: Repair of a brick wall

Figure 12: Restoration of parts of a building

Rehabilitation is similar to repair, but assumes that the original materials may have deteriorated so much that some parts may have to be replaced with same or similar materials so as to bring the building as close as possible to its original strength.

In a retrofit programme, the building's seismic deficiencies are ascertained and efforts are made to improve its strength and earthquake resisting properties so that the building is significantly upgraded from its original form.

6.2.1 Why retrofit buildings

The need for retrofitting arises in the following scenarios:

- Building is not designed according to the building code
- Subsequent updating of code
- Subsequent upgrading of seismic zones (e.g., in the 2002 revision of the IS Code, Chennai was upgraded from Zone II to Zone III)
- Deterioration of strength and ageing of the building
- Change in use of the building (e.g. if a building functioning as a residential apartment has been converted into a hospital, and thus, is classified as 'important')

6.2.2 Performance-based engineering

In the development of our building codes, the primary concern has always been the safety of the occupants of the building in an earthquake. However, of late, the focus has shifted to keeping critical buildings such as hospitals functional following earthquakes. Internationally, earthquake engineers use performance-based earthquake engineering (PBEE) procedures to design structures with predictable and defined seismic performance. These set the acceptable level of damage to the building, if an earthquake of specified intensity affects the building. These levels, known as the four performance levels, could be as basic as 'collapse prevention' or a higher 'life safety' to 'Immediate occupancy' and the highest of 'fully operational'. The performance of non-structural elements, (such as false-ceilings, furniture and glass panels) and utility systems in buildings (electricity, water supply and related equipment) are important to ensure the building functions in the higher performance levels.

Performance-based engineering and the BIS codes:

The draft revision of the IS code IS: 1893 includes an informative annexe on Performance Based Design, with four levels of performance, a) Operational; b)

Immediate Occupancy; c) Life Safety; and d) Collapse Prevention. The annexe describes performance objectives as: 'A desired level of seismic performance, expressed in terms of acceptable structural and non-structural damage for a specified level of seismic hazard'.

Importance of PBEE in retrofitting:

PBEE is an important consideration in the retrofitting of buildings and one of the first steps in the retrofitting process is to have discussions with the owners of the building to understand the desired performance level of the retrofitted building. Once the performance level is finalised, the building is assessed as per the level and if found to be deficient, the retrofitting solutions are worked out.

6.2.3 Steps to retrofit a building

1. **Setting hazard levels:** It is essential to gauge the hazard levels that the building is expected to be subjected to in its lifetime.

2. **Setting performance objectives:** The need for good performance of a building will depend on the criticality of the functions of the building, the age and condition of the building and the budget available for the retrofit.

3. **Finding out as-built conditions:** Engineers try to understand the conditions under which the building was designed and constructed to enable more focused analysis of the building.

4. **Non destructive testing:** There is a common misconception that testing of materials in the existing building is the sole determining factor for retrofit design. Many agencies that carry out Non-Destructive Testing (NDT) of building elements over-emphasises the need for NDT before retrofitting. Earthquake performance of a building depends more on the rigour of code compliance during design and construction than quality of a portion of a column or beam.

5. **Computer analysis of the building:** Once the drawings are in place, as built conditions and soil characteristics of the building are known, computer models are created to determine

Figure 13: Retrofitting - Before and after

the approximate strength of the structure and the importance of various parts, both for earthquake and gravity load carrying purposes.

6. **Basket of retrofitting solutions**: Technical issues such as strength, stiffness, ductility, connectivity etc. will determine structural retrofit solutions. Non-technical considerations will govern the final selection of the retrofit scheme in consultation with the client. These include construction cost, performance expectations, aesthetics, disruption etc.

7. **Cost estimation**: Once the retrofitting scheme has been finalised, the engineering team can work out detailed cost estimates and plan the project. Again, it will be important to involve the client in this process to develop a disruption plan for the retrofitting.

8. **Call for contractors**: It is important to call for contractors who have worked extensively in retrofitting projects with an understanding of the earthquake behaviour of buildings. This will include the process to be followed, the time schedule, quality control mechanisms and review protocols and the disruption plan.

6.2.4 Steps in a municipal retrofitting programme

1. **Understanding the hazard**: At the outset, it is important to understand the earthquake zone the city is in and the likely Intensity of shaking.

2. **Selection of buildings for retrofitting**: Since all buildings vulnerable to earthquake damage in a city cannot be retrofitted because of their sheer number, the city will have to prioritise buildings as per select criteria. An initial list of important buildings can be selected from each department and further prioritisation can be carried out. The criteria can be a building's current functional role, symbolic importance to the community, heritage status, age and condition. Use and function is a useful starting point for shortlisting buildings for retrofitting.

3. **RVS of buildings**: An RVS programme is initiated for understanding the broad strengths and vulnerabilities of the set of buildings that have been prioritised. The recommendations of the RVS results will be one of the criteria for prioritising and selecting buildings to be retrofitted.

4. **Developing retrofitting programme**: Once the list of the buildings has been finalised, discussions on the retrofitting programme can be initiated

with the respective government departments, such as the Department of Education in the case of a school retrofit. It will be important for the departments concerned to be funding the retrofitting programmes on their own and also involving their engineering staff members in the retrofitting programme.

5. **Gathering resources:** The municipality itself will have to plan for coordinating a retrofitting programme and allocate resources for the effort. Organising technical personnel for carrying out the retrofitting will have to be sourced from within departments. Alternatively, training programmes must be organised to build capacities of departmental engineers.

6.2.5 Retrofitting measures for other hazards

The word 'retrofit' means to add a component to something that did not have it when manufactured. Besides seismic retrofitting, this could include green retrofit, deep energy retrofit, wind retrofit and flood retrofit, as explained below:

Green retrofit: Any kind of upgrade of an existing building that is wholly / partially occupied to improve energy and environmental performance, reduce water use, and improve the comfort and quality of the space in terms of natural light, air quality, and noise—all done in a way that it is financially beneficial to the owner. (Source: U.S. Green Building Council)

Energy retrofit: Energy retrofitting is the process of upgrading a building's energy-consuming systems that may involve improving or replacing lighting fixtures, ventilation systems, or windows and doors, or adding insulation where it makes economic sense. (Source: Natural Resources Canada)

Wind retrofit: The process of upgrading a building to reduce the vulnerability to wind and wind-driven rain intrusion during a high-wind event such as a cyclone. Generally, there are three areas of the home that are typically vulnerable to failure due to high winds: - a) Roof and wall coverings; b) Openings (e.g., windows, doors); and c) Load path connections (the connections of each part of the structure, from roof to foundation). (Source: FEMA P-804-Wind Retrofit Guide for Residential Buildings)

Flood retrofit: Making changes to an existing building to protect it from flooding. Generally, there are four ways of making a building flood resistant: - a) raising

the floor level so that the lowest floor is above the flood level; b) wet flood-proofing by making low lying parts of the building resistant to flood damage even if water enters during flooding; c) dry flood-proofing i.e. sealing the building to prevent flood waters from entering it; and d) flood wall or sandbag protection i.e. constructing barriers to prevent flood waters from entering the building. (Source: FEMA P-312, Homeowner's Guide to Retrofitting)

Essential measures for retrofitting are provided in Annexure 3.

7. Policies, Plans and Legislations

7.1 National Disaster Management Act, Policy and Plan

The Disaster Management Act of 2005 laid down the foundation for disaster management (DM) institution building and planning in the country. The National Policy on Disaster Management aims to bring about a paradigm shift from a relief-centric approach to one covering prevention, preparedness and mitigation, and efforts on mainstream prevention and mitigation measures into the developmental plans and programmes by enlisting cooperation from all stakeholders. Key facets of the Policy are summarised below.

Integrating Disaster Management in Developmental Plans – There is provision for mainstreaming of DM in the developmental agenda of all existing and new developmental programmes and projects which shall incorporate disaster resilient specifications in design and construction.

Responsibilities of the Ministries and Departments – The Policy states that all Central Ministries and Departments will prepare their DM plans including the financial projections to support these plans. The necessary budgetary allocations will be made as part of the Five Year and Annual Plans. At state and district level, it shall be the responsibility of the States to constitute Disaster Mitigation and Response Funds.

Techno-Financial Regime – The Policy provisions for new financial tools such as catastrophe risk financing, risk insurance, catastrophe bonds, micro-finance and insurance etc., to be promoted with innovative fiscal incentives to cover losses of individuals, communities and the corporate sector.

The National Disaster Management Plan, released in 2016, emphasises the alignment of the national approach to DM with the Sendai Framework for Disaster Risk Reduction (2015-2030). It focuses on understanding risk, strengthening governance, investing in resilience, and being prepared. It also identifies specific hazards, response actions and responsibilities of concerned stakeholders.

7.2 Five Year Plan

Five-Year Plans are centralised and integrated national economic programmes. These Plans chart the development path for the declared objectives of the Government to promote a rapid rise in the standard of living of the people by efficient exploitation of the resources of the country, increasing production and offering opportunities to all for employment in the service of the community.

7.3 National Housing Policy

The National Housing Policy was adopted in August 1994. Under this Policy, for participatory approach to shelter development within policy and institutional framework, partnerships between Government, private sector, non-governmental organisations (NGOs) and community-based organisations (CBOs) needs to be encouraged. Incentives such as access to land, finance, technology, procedure rationalisation, and legal modification for an enabling environment need to be provided. Skills of the vulnerable group need to be upgraded and power needs to be decentralised.

7.4 National Building Code, 2005

The National Building Code of India, a comprehensive building code, is a national instrument providing guidelines for regulating the building construction activities across the country. It serves as a Model Code for adoption by all agencies involved in building construction works, including Public Works Departments, other government construction departments, local bodies and private construction agencies. The Code mainly contains administrative regulations, development control rules and general building requirements; fire safety requirements; stipulations regarding materials, structural design and construction (including safety); and building and plumbing services.

7.5 Environmental Protection Act, 1986

The Environment (Protection) Act was enacted in 1986 with the objective of providing for the protection and improvement of the environment. It empowers the Central Government to establish authorities charged with the mandate of preventing environmental pollution in all its forms and to tackle specific environmental problems that are peculiar to different parts of the country.

7.6 National Urban Housing and Habitat Policy

The National Urban Housing and Habitat Policy (NUHHP), 2007 seeks to use the perspective of Regional Planning as brought out in the 74th Amendment Act in terms of preparation of District Plans by District Planning Committees and Metropolitan Plans by Metropolitan Planning Committees as a vital determinant of systematic urban planning. The Policy seeks to promote a symbiotic development of rural and urban areas. In this regard, the Policy seeks to ensure refinement of Town and Country Planning Acts (wherever required) and their effective implementation. The core focus of this Policy is provision of "Affordable

Housing For All", with special emphasis on vulnerable sections of society such as scheduled castes/scheduled tribes, backward classes, minorities and the urban poor. The new NUHHP is expected in 2017.

7.7 National Urban Sanitation Policy

The overall goal of this Policy is to transform urban spaces in India into community driven, healthy and liveable areas. The specific goals are:

- Awareness generation and behaviour change
- Achieving open defecation free cities
- Re-orienting institutions and mainstreaming sanitation
- Sanitary and safe disposal
- Proper operation and maintenance of all sanitary installations

7.8 National Urban Transport Policy

The objective of this Policy is to plan for the people rather than vehicles, by providing sustainable mobility and accessibility to all citizens to jobs, education, social services and recreation at affordable cost and within reasonable time.

7.9 Key Legislations

The 74th Amendment Act, 1992

The 74th Constitution Amendment Act, 1992 gives constitutional recognition to the urban local bodies along with the constitutional right to exist. The Act requires the state governments to amend their municipal laws in order to empower ULBs with such powers and authority as may be necessary to enable them to function as institutions of self-governance.

The Land Acquisition Act, 1894

Under this Act, the Collector of the district or any other officer specially appointed by the government can notify the land required for public purpose for intended acquisition. After the award of the compensation/damages, the Collector has the powers to acquire land.

The Slum Areas (Improvement and Clearance) Act, 1956

The Act empowers the government to clear slums by demolishing unsuitable houses and redeveloping the congested and blighted areas to improve the lot of the unfortunate residents residing therein.

The Urban Land (Ceiling and Regulation) Act, 1976

The main function of this Act is to limit the holding of land by any person to a certain limit. The limit for vacant land in urban agglomeration is 500 sq.m. The competent authority to be appointed by the State Government governs the powers under the Act. Urban Land Tribunals could be set up by respective governments to sort out grievances of persons by the competent authority.

7.10 City Specific Legal Instruments

City specific legal instruments are prepared to legalise the development needs of a specific city and provide a platform for contextual development of the city. Taking the example of Delhi, the following acts have been enacted for appropriate development of the city:

- Delhi (Control of Building Operation) Act, 1955
- The Delhi Development Act, 1957
- The Delhi Municipal Corporation Act, 1957
- The Delhi Rent Control Act, 1958
- The Delhi Land Holding (Ceiling) Act, 1960
- The Delhi Lands (Restriction on Transfer) Act, 1972
- The Delhi Urban Art Commission Act, 1973
- The National Capital Region Planning Board Act, 1985
- Delhi Apartment Ownership Act
- Metro Railways Construction Act 1978
- The Delhi Municipal Corporation Act 1957 and later amendments
- Unified Building Bye Laws of Delhi, 2016

7.11 Regulatory Instruments

Perspective Plan

Developing a vision for the development area is essential for policy framework. The vision stipulates direction of growth and identification of resource potential and innovations to be adopted for the thrust areas of development. It integrates broad level plan with the regional or development plan. A realistic vision helps policy formulation and preparation of perspective plan.

Regional Plan

Regional plan is a comprehensive plan at an appropriate scale (district/inter district, investment region or special area) for the integration of urban nodes with the semi-urban and rural areas. The plan is based on understanding of

the characteristics of the region such as flow of people, goods, knowledge and money.

Master Plan

Master plan is a statutory plan prepared within the framework of an approved perspective plan. The objective of this plan is to provide further necessary details and intended actions in the form of strategies, land uses and physical proposals for various approaches given in the perspective plan and regional plan depending upon the economic and social needs and aspiration of the people, available resources and priorities.

Land Use Plan

The land use plan synthesises the policies for different urban activities, requirements of physical and social infrastructure, transportation and work centres, restructuring of land use based on inter-relationship of urban activities, environment and the important transport routes.

Development Code

The development code aims to improve quality of life of the people by facilitating appropriate development of land in accordance with the developmental policies and land use proposals.

Zonal Development Plans

These plans are expected to contain sub city plans and uses for the development of a zone for various activities as per norms and standards of the Master Plan.

Building bye-laws

Unified building bye-laws should be prepared to control the building activities occurring in areas under the jurisdiction as well as to ensure that all buildings conform to certain minimum safety and health standards. While sanctioning the building plan on a plot which is part of a colony, norms prescribed in the development code are applicable as part of building regulations and requirements of the building byelaws are to be fulfilled.

7.12 Real Estate (Regulation & Development) Act, 2016

It is an Act to establish the Real Estate Regulatory Authority for regulation and promotion of the real estate sector and to ensure sale of plot, apartment or building, as the case may be, or sale of real estate project, in an efficient and

transparent manner and to protect the interest of consumers in the real state sector and to establish an adjudicating mechanism for speedy dispute redressal and also to establish the Appellate Tribunal to hear appeals from the decisions, directions or orders of the Real Estate Regulatory Authority and the adjudicating officer and for matters connected therewith or incidental thereto.

8. Instruments for Implementation of Disaster Risk Reduction

The enforcement of a technolegal regime conducive to DRR implementation requires an inclusive approach that brings in all stakeholders on a common platform to share experiences and learnings. For a safer built environment, the following strategy should be adopted:

1. **Development control regulations and byelaws**: To regulate development within the framework of a development plan regulation, known as development promotion regulation prescribed as a part of the development plan.

2. **Structural design**: To ensure the compliance of various codes, a Structural Engineer on Record is required to submit a Structural Design Basis Report in prescribed template for applicable type of structures. Provision for proof checking of design by a senior structural engineer has to be introduced.

3. **Multi-hazard proofing**: Prior to seismic strengthening/retrofitting of any existing structure, evaluation of the existing structure as regards structural vulnerability in the specified wind/seismic/flood hazard zone shall be carried out by a registered structural engineer. Local context specific hazards such as water logging, fire incidents etc. should also be assessed.

4. **Supervision and quality control**: All construction should be carried out under the supervision of a Construction Engineer. To ensure proper quality, it is recommended that all the construction for highrise buildings higher than seven storeys, public buildings and special structures shall be carried out under quality inspection programme prepared and implemented under Quality Auditor on Record or Quality Auditor Agency on Record in seismic zones IV and V. Adequate signage should be installed on all construction sites. Specific requirements for children, women, elderly and differently abled should also be addressed in the construction of buildings.

5. **Expansion of buildings**: The expansion of building should be in line with the zoning regulations and should be approved by the competent authority.

6. **Maintenance of buildings**: Provisions should be made for safety of buildings, with specific attention to buildings older than 50 years. It shall be the duty of the owner of a building to get his/her building inspected by a Registered Structural Engineer. The Structural Inspection Report shall be

produced by the owner to the appropriate authority. Within a stipulated reasonable time period, action as required will have to be taken to rectify/ strengthen as recommended in the report.

7. **Improving public awareness:** People have to be aware of the existing technolegal regime so that they can fulfill their responsibilities and avail their rights easily. Usually, lack of knowledge leads to breaking of regulations. Awareness campaigns need to be launched for outreach to larger community.

8. **Engagement of local stakeholders through participatory process:** Local stakeholders should be engaged in different stages of activities from planning to implementation. This helps in buy-in of end users and also increases the ownership of the activity carried out. Encouragement of participatory processes ensures inclusion of voices of all community groups.

9. **Incentives for safety features and retrofitting:** Incentives mechanism should be set for people who undertake more safety features or retrofitting of their buildings. Incentives could be insurance, tax concession or other benefit based. This will promote safe building practices in the city.

10. **Risk informed planning:** The HRVCA carried out should be circulated widely in all line departments to plan their works based on the risks and hazards identified. This will enhance the results of the activities and minimise the losses.

11. **Risk sensitive budgeting:** The budgets need to be planned in a manner so that the planned activities for safeguarding the city should be less exposed to risks. This requires for a risk sensitive budgeting and financial planning to secure the planned activities from hazards and create a sound platform for sustained economic development. Departmental plans of government should allocate a fixed percentage of annual budget for integrated risk management. Various departments need to make provisions in their annual budget to fund the activities and programmes set out in the integrated risk management plan.

12. **Capacity Building for DRR:** Training is an integral component of capacity building. However, it needs to be designed for specific needs and equipped with a practical technically sound approach. Strengthening of resources and information is also essential for optimal capacity building. Role players in disaster management include government organisations, NGOs,

CBOs, international development aid agencies and donors, academic institutions, private sector organisations, religious organisations, defence, police, media and the community. Since each of these have specific work areas, strengths and weaknesses, it is important for them to complement each other's efforts for putting in place an efficient DM system. It has to be a true enterprise of public-private partnerships in the flow of skills, finances and specialised personnel or institutional knowledge. Media can play an important role in highlighting the vulnerability of the community during a disaster and can become an active medium for awareness. The construction industry, especially capacity building of construction workers including masons, requires specific attention as the last mile link for ensuring safety of the built environment.

13. **Ensuring safety and functionality of critical infrastructure and evacuation points:** The impact of sudden, high intensity disasters is devastating not only on people, but also buildings and infrastructure. Buildings like hospitals, schools, administrative centres, fire service and police stations, community halls etc. serve critical functions in responding to a disaster event. While hospitals, administrative centres and control rooms are critical in responding to an emergency, schools, community and meeting halls perform emergency functions as evacuation centres and relief camps. Structural and non-structural damage to such buildings not only risk the lives of those inside the building at the time of disasters like critically ill patients in hospitals or children in schools but also hampers quick response to the calamity. Therefore, preparedness and mitigation measures should include retrofitting of lifeline buildings for not only saving lives of the vulnerable people, but also to ensure prompt and efficient response to disasters.

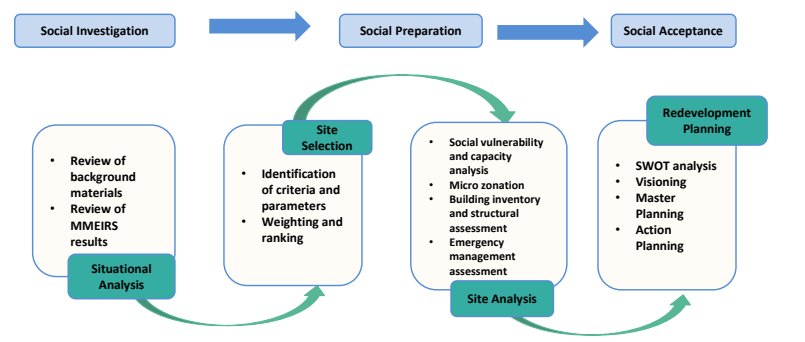
Box 4

Case: Disaster Risk Reduction of Highly Vulnerable Urban Areas through Urban Re-Development, Makati, Philippines

This was a one of its kind project in the Philippines to address the redevelopment of a built-up urban area, keeping in mind the reduction of risk. The project framework for risk-sensitive urban redevelopment included sustainability, livability and disaster risk/ vulnerability (planning parameters) as the core considerations for the redevelopment planning of the pilot site.

Further, the community and stakeholders' participation and political support was applied cross-sectorally to identify and validate site development planning considerations; to assess and

validate disaster risk and vulnerability; to identify issues/problems, goals, objectives; to develop and identify strategies and programs, projects and activities; to develop, validate and advocate alternative scenarios; and to refine and select the most appropriate initiatives and ordinance containing institutional framework.



Through this project it was shown successfully that formulating an acceptable redevelopment plan is possible if the planning process is systematic, transparent, participatory and consensus-based. The systematic approach in data gathering, analysis, and presentation at the stakeholder workshops helped significantly in developing a deeper appreciation of the risks that the community faces. A strong multi-disciplinary technical team is needed to collect the detailed data and integrate the many parameters driving the redevelopment while at the same time pursuing the participatory approach. The sensitivity of the City Government representatives and technical experts to the particular culture, socioeconomic circumstances, and constraints on the part of the affected households was especially helpful in maintaining a spirit of collaboration and cooperation throughout the planning process. The project demonstrated that land use and redevelopment planning can be powerful tools to lessen the physical, social, and economic vulnerability of high-risk communities.

Source: www.alnap.org/pool/files/rsurp-mkt-usmca2010.pdf

Strategy for the Enforcement of Techno-Legal Regime for Safer-built Environment

The enforcement of techno legal regime leading to disaster risk reduction requires an inclusive approach that brings in all stakeholder at a common platform to promote a safe and resilient habitat

Development control regulations and byelaws

This helps to regulate development within the framework of a development plan

Structural Design

Compliance of codes	Adherence to the prescribed design template	Proof-checking of the design by a senior structural engineer

Multi-hazard proofing

Vulnerability assessment of the existing structure in the hazard prone areas must be conducted by a registered structural engineer

Supervision and quality control

Construction must be carried out under supervision of Construction Engineer.

Construction of high-rise buildings, public buildings and special structures should be carried out under qualified technical experts

Adequate safety signage should be installed on all construction sites.

Specific requirements for children, women, elderly and differently abled should be addressed in the construction of buildings.

Expansion & Maintenance of buildings

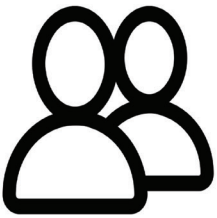
The expansion of physical infrastructure must conform to the zoning regulations and approved by the competent authority.

The owner must get the building inspected by a certified structural engineer and the report must be produced to the appropriate authority

Improving Public Awareness

Awareness campaigns on existing techno-legal regime to make people aware of the importance of safe construction and their role in promoting building of safe habitat

Engagement of local stakeholders through participatory process



Participatory approach to ensure involvement of all the key stakeholders. This ensures accountability and sustainability

Incentives for safety features and retrofitting

Introduce incentives such as insurance, tax concession or other benefits to promote safe building practices in the city

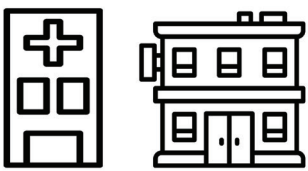
Risk informed planning and budgeting

Line departments must prepare plans based on through risk assessment. Budgeting should take into consideration the critical requirements and ensure sustained economic development

Capacity building for DRR

Identify the key stakeholders and equip them with necessary skills to ensure sustainable disaster management. A contingent of trained human resource can go a long way in mitigating the disaster risks

Ensuring safety and functionality of critical infrastructure and evacuation points



Retrofit the lifeline buildings such as hospitals, Emergency Operation Centres (EOCs), fire-stations etc to ensure prompt and efficient response to disasters

Box 5

Indian Standards/Codes Relating to General Structural Safety from Natural Hazards

For General Structural Safety

1. IS: 456:2000 "Code of Practice for Plain and Reinforced Concrete (Fourth Revision)
2. IS: 800-1984 "Code of Practice for General Construction in Steel (Second Revision)
3. IS: 801-1975 "Code of Practice for Use of Cold Formal Light Gauge Steel Structural Members in General Building Construction (Second Revision)
4. IS 875 (Part 2):1987 Design loads (other than earthquake) for buildings and structures Part2 Imposed Loads (Second Revision)
5. IS 875 (Part 3):1987 Design loads (other than earthquake) for buildings and structures Part 3
6. Wind Loads (Second Revision)
7. IS 875 (Part 4):1987 Design loads (other than earthquake) for buildings and structures Part 4 Snow Loads (Second Revision)
8. IS 875 (Part 5):1987 Design loads (other than earthquake) for buildings and structures Part 5 special loads and load combination (Second Revision)
9. IS 883:1966 "Code of Practice for Design of Structural Timber in Building (Fourth Revision)
10. IS 1904:1987 "Code of Practice for Structural Safety of Buildings: Foundation" (Third Revision)
11. IS 1905:1987 "Code of Practice for Structural Safety of Buildings: Masonry Walls (Third Revision)
12. IS 2911 (Part 1): Section 1: 1979 "Code of Practice for Design and Construction of Pile Foundation (First Revision)

    Part 1: Section 2 Based Cast-in-situ Piles

    Part 1: Section 3 Driven Precast Concrete Piles

    Part 1: Section 4 Based precast Concrete Piles

    Part 2: Timber Piles

    Part 3: Under Reamed Piles

    Part 4: Load Test on Piles

8.1 Measures for Ensuring Compliance with Building Codes, Bye Laws, Land Use and Zoning Regulations

The following measures should be undertaken for ensuring compliance with building codes, bye laws, land use and zoning regulations:

1. **Improved awareness:** People in general are not very aware about existing building codes, bye laws, land use and zoning regulations. Specific steps should be taken to increase city/regional level awareness. A city level campaign to be organised to reach local people and sensitise them about the existing regulations. This will develop an informed decision making system as people will already be aware leading to lesser compliance issues.

2. **Transparency:** The process for dealing with compliances should be very transparent. This will create trust among people and will encourage citizens to follow the regulations efficiently. To ensure transparency, online platforms should be used where anyone can view the current status of their filed processes or complaints.

3. **Safety and quality audit:** Third party quality audit is a requirement for an independent assessment of the quality and seismic or cyclone resistant features of all the highrise buildings in earthquake zone IV and V and coastal areas of the country. The quality audit report shall consist of conformance or non-conformance of structures with the technical specifications for earthquake and cyclone resistance and to suggest remedies/rectification, if any. The same should apply for fire and other risks in all urban areas.

4. **Non-structural mitigation:** In most earthquake scenarios, only a small percentage of damaged buildings totally collapses. In many heavily and moderately damaged buildings and even in some slightly damaged buildings, non-structural hazards account for serious injuries and huge economic losses. Non-structural mitigation measures need to be taken in all the critical infrastructure buildings and government offices. Awareness needs to be created in the city about the importance of non-structural mitigation and how it can reduce life threats.

5. **Mason training:** The need for safe infrastructure and resilient buildings can only be met if there is a trained capacity to fulfil the demand. Masons and construction workers play the most vital role in building a city and so is their role in making the city safer. Masons and construction workers

such as fabricators, bar benders, carpenters and plumbers, thus, need to be trained on safer building practices for hazard proofing the built environment.

6. **Enhance enforcement capacity**: Human resource capacity required for the adequate service delivery should be assessed regularly based on the planned development of the city. The enforcement capacity should include the required personnel at various levels to carry out the required services in an effective manner. This will require qualified and trained personnel in various departments and agencies at all levels.

7. **Widen the net**: Informal settlements constitute a large section of the city dwellers and need to be included in the mainstream society. For enforcement of building bye laws and zoning regulations in the informal settlements, local orders can be passed along with the community leaders. The approach will need to be appropriately designed and based more on Mandatory Rules of Thumb. This will ensure better planned and safer development across all sections of the city.

8. **Including peri-urban areas**: Land that is on the outskirts of the city boundary undergoes significant transformations that are both beneficial and detrimental to the quality of life. While city governments are unable to provide for the surge of population, the rural areas just outside the city start cashing in on the demand for products, services and land for the growing economy. This degrades the built environment in the peri-urban areas. These areas should be included under the influence zone of safety planning. District authorities will need to be brought on board for this purpose.

Box 6

Making Cities Resilient Campaign

UNISDR and its partners are working towards sustainable urbanisation by taking proactive actions.

The Making Cities Resilient campaign launched in May 2010 addresses issues of local governance and urban risk. The campaign is led by the UNISDR but is self-motivating, partnership- and city-driven, with an aim to raise the profile of resilience and DRR among local governments and urban communities worldwide.

The objectives of the Making Cities Resilient Campaign are:

- **Know more:** Raise awareness of citizens and governments at all levels of the benefits of reducing urban risks
- **Invest wisely:** Identify budget allocations within local government funding plans to invest in disaster risk reduction activities
- **Build more safely:** Include DRR on participatory urban development planning processes and protect critical infrastructure

Source: http://www.unisdr.org/campaign/resilientcities/

TEN ESSENTIALS

The Ten Essentials for Making Cities Resilient developed at the launch of the Campaign in order to accelerate implementation of the Sendai Framework for Disaster Risk Reduction (2015-2030) at local level are:

Essential One: Organise for Disaster Resilience

Essential Two: Identify, Understand and Use Current and Future Risk Scenarios

Essential Three: Strengthen Financial Capacity for Resilience

Essential Four: Pursue Resilient Urban Development and Design

Essential Five: Safeguard Natural Buffers to Enhance Ecosystems' Protective Functions

Essential Six: Strengthen Institutional Capacity for Resilience

Essential Seven: Understand and Strengthen Societal Capacity for Resilience

Essential Eight: Increase Infrastructure Resilience

Essential Nine: Ensure Effective Disaster Response

Essential Ten: Expedite Recovery and Build Back Better

9. Role of Urban Managers

More than a quarter of urban population in India lives in metropolises and mega cities. In 2025, the urban component would be more than 50 percent. This increase in urban population also indicates the ramification of disasters on them. The vulnerability is further magnified by weak socioeconomic structures in most of the cities, where 30 to 60 percent of the population lives in slums and squatter settlements. The need for DM exclusively for the urban set up is emphasized by the uniqueness and high magnitude of vulnerability to disasters.

Urban local bodies need to play a major role in the disaster preparedness planning. Major roles of the urban local bodies before and after a disaster are:

- Preparation and updation of DM plans
- Participation and coordination in response activities
- Conducting activities such as damage assessment and relief distribution for recovery from the event

9.1 City Disaster Management Plan

When disasters threaten or strike a jurisdiction, people expect elected leaders and city officials to take immediate action to deal with the problem. The urban local body is expected to marshal its resources, obtain and channelise the efforts of voluntary organisations and private sector organisations in the city, and solicit assistance from outside of the jurisdiction if necessary. A City Disaster Management Plan (CDMP) puts all these activities in a process form and guides officials to take decisions promptly for managing any emergency situation.

Capacity building and exercises, in particular, depend on a DM plan. Training helps emergency response personnel to become familiar with their responsibilities and to acquire the skills necessary to perform assigned tasks. Exercising and drills provide a means to validate plans, checklists, and response procedures and to evaluate the skills of response personnel.

Second, the DM plan facilitates response and short-term recovery (which set the stage for successful long-term recovery). Response actions are time-sensitive, with little allowance for delay or mid-course corrections. Post-disaster mitigation issues such as rebuilding and placement of temporary housing facilities must be addressed timely. Advance planning makes this easier.

Finally, a DM plan that is flexible enough for use in all emergencies—including unforeseen events--provides a community with an emergency management

"bottom line." From there, a community can proceed confidently with long-term mitigation efforts directed at specific hazards. Or, it can devote more resources to risk-based preparedness measures (e.g., specialised training, equipment, and planning). Whatever the initiative, an all-hazard CDMP helps the community start from a position of relative security.

9.2 Steps for Preparing A City Disaster Management Plan[2]

1. **Conduct research:** The first step consists of reviewing the city's planning framework, analysing the hazards faced by the city, determining the resource base, and noting characteristics of the city that could affect emergency operations.

   Review of local and/or State Act and laws, rules, regulations, executive orders, etc., that may be considered enabling legislation must be carried out. Review of regulatory requirements, any existing plans for the jurisdiction, and the plans of neighbouring cities is important. It is also advisable to be familiar with the plans of higher levels of the government that may be called on to provide assistance.

2. **Conduct HRVA:** Hazard analysis is the basis for both mitigation efforts and CDMPs. From a disaster planning perspective, hazard analysis helps a planning team decide what hazards merit special attention, what actions must be planned for, and what resources are likely to be needed.

3. **Determine resource base:** Agency heads and other potential members of the planning team should know what kinds of resources they can bring to disaster response and recovery. The task is to quantify and list them, and compare the resources available to the resources needed for an effective emergency response. Shortfalls may require negotiating agreements with private suppliers. Determination of the resource base also should include a consideration of what facilities are vital to emergency operations and how they might be affected by hazards. Problems that cannot be mitigated should be taken into account in the CDMP.

4. **Note special aspects of the environment:** The planning team should note geographic and topographic features that may affect operations--for example, dependence on a single main transportation artery/ bridge in and out of the city. Planners also should identify special need groups

[2] *A Manual for the Development of Municipal Disaster Management Plans for Floods, Cyclones, Earthquake and Fire Hazards for Urban Local Bodies of Andhra Pradesh, India.*
http://www.umcasia.org/uploads/A_Manual_for_the_Development_of_Municipal_Disaster_Management_Plans_for_Floods_Cyclones_Earthquake_and_Fire_hazardspdf.pdf

(diverse language speakers, the aged, the disabled) and where they are concentrated (especially institutions such as nursing homes). Finally, the planning team should be alert to demographic and other trends in the jurisdiction that affect assumptions.

5. **Develop a DM Plan:** The steps involved in creating a CDMP are:

   1. Develop a rough draft of the basic plan, hazard specific actions and functional annexes to serve as a point of departure for the planning team.
   2. Plan and conduct a first round of meeting with planning team, key officials, elected members, and NGOs.
   3. Conduct a presentation meeting, establish committees for parts of the CDMP, appoint committee chairs, and schedule a follow-up meeting.
   4. Work with committees on successive drafts.
   5. Prepare necessary graphics (e.g., maps, organisational charts).
   6. Produce a final draft and circulate the draft to the planning team for review and comment.
   7. Hold a meeting to incorporate final changes, discuss an implementation strategy and necessary distribution.
   8. Obtain concurrence from organisations with identified responsibilities for implementing the CDMP.
   9. Present the CDMP to local elected officials and obtain official sanction of the plan (advise the local media in advance).
   10. Print and distribute the CDMP, with a copy (or press release) to local media. Maintain a record of the organisations and persons that received a copy (or copies) of the plan.

6. **Validation:** The written CDMP should be checked for its conformity to applicable regulatory requirements and conformity to the AP State Act and for its usefulness in practice. Further, a "table top" exercise involving the key representatives of each tasked organisation may serve as a practical and useful means to help validate the plan.

7. **Plan Review:** Consult whether the CDMP is to be reviewed by the District Collectorate office or any agency at the state level. This will allow these agencies to suggest improvements/ coordination in the CDMP based on their accumulated experience.

8. **Plan Testing:** To evaluate new or revised CDMP, use functional and full scale emergency management exercises. Exercises offer the best way, short of emergencies, to determine if the CDMP is understood and is useable.

9. **Maintenance:** The CDMP is a living document and must be updated on a routine basis to ensure it is adjusted to changes that occur over time within the city.

10. **Remedial Action Process:** A remedial action process can help a planning team identify, illuminate, and correct problems with the CDMP. A remedial action process captures information from exercises, post-disaster critiques, self-assessments, administrative reviews, and the like, which may indicate that deficiencies exist. It then brings members of the planning team together to discuss the problem, and to consider and assign responsibility for remedies. Remedial actions may involve revising planning assumptions and operational concepts, changing organisational tasks, or modifying organisational implementing instructions. They also may involve refresher training on performance of tasks assigned by the CDMP to an organisation's personnel. The city should fix up a timeframe for revision of the CDMP in the event of no major emergency incidence.

11. **Plan Distribution and Approval:** At a minimum, the copies of the initial and subsequent updates of the CDMP should be provided to the following:
    - The City Mayor
    - The Municipal Commissioner
    - All City Department Heads
    - The City Clerk
    - The City Emergency Control Room
    - District Collector
    - District Collector Control Room

    Each City department head is responsible for further distribution of copies of the CDMP to specific departmental personnel, as decided. Minor changes to the plan may be made via change pages and distributed to plan holders. Major changes that significantly alter operational concepts, assignment of responsibilities, or the location/type of designated emergency facilities will result in distribution of an entire copy, as modified.

City Disaster Management Plan

Steps for preparation of City Disaster Management Plan

Carry out a detailed research

Review the city's planning framework, analyse the past hazards, determine the resource base and note the key characteristics of the city that can guide the emergency operations

Conduct Hazard Risk and Vulnerability Anaysis (HRVA)

HRVA helps in strategic planning by way of analysing the risks, vulnerability and coping capacity to take guided initiatives

Determine the resource base

Map and list the existing capacity. Identify the gaps and take suitable initiatives for effective disaster response and recovery

Geographic, topograhic and demographic characteristics

A detailed analysis of geographic, topographic and demographic characteristics are must for mitigation and disaster response and recovery

Develop a disaster management plan

A detailed plan that documents the key roles and responsibilities of all stakeholders, risk analysis, vulnerability, emergency support system etc. to serve as a ready reckoner for the line departments to take appropriate actions

Validate the plan

The plan must be tested and validated for its effectiveness. Conduct mock drills, table-top exercises with involvement of key departments to ensure efficacy of the plan

Review the plan

The plan must be reviewed at the state level by various departments to suggest any improvements and ensure inter-departmental coordination

Test the plan

Test the plan through use of functional and full scale emergency management exercises

Regular updation of the plan

The plan must be updated from time to time to reflect any changes in the organisation, key officials, rules and regulations, resource inventory etc

Remedial action process

Remedial action process helps in identifying and highlighting the problems in the disaster management plan so that corrective actions can be taken

Plan distribution and approval

The plan must be distributed to the key government officials such as Collectors, Mayors, Municipal Commissioner, key departments etc

9.3 Important Aspects to Cover while Preparing a CDMP

9.3.1 Ensure inclusion of all phases in a DM cycle

DM aims to reduce, or avoid, the potential losses from hazards, assure prompt and appropriate assistance to victims of disaster, and achieve rapid and effective recovery. The DM cycle illustrates the ongoing process by which governments, businesses, and civil society plan for and reduce the impact of disasters, react during and immediately following a disaster, and take steps to recover after a disaster has occurred. Appropriate actions at all points in the cycle lead to greater preparedness, better warnings, reduced vulnerability or the prevention of disasters during the next iteration of the cycle. The complete DM cycle includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure.

The four DM phases illustrated below do not always, or even generally, occur in isolation or in this precise order. Often, phases of the cycle overlap and the length of each phase greatly depends on the severity of the disaster.

1. **Mitigation -** Minimizing the effects of disaster
   Examples: Building codes and zoning, vulnerability analyses and public education.
2. **Preparedness -** Planning how to respond
   Examples: Preparedness plans, emergency exercises/training and warning systems.
3. **Response -** Efforts to minimize the hazards created by a disaster
   Examples: Search and rescue and emergency relief.
4. **Recovery -** Returning the community to normal.
   Examples: Temporary housing, grants and medical care.

Box 7

Build Back Better

Recovery and reconstruction is an opportunity to remedy pre-existing problems and avoid, or mitigate the impact of, recurrences. Timely and efficient technical and financial resource mobilisation is required to support build back better after a disaster, and national and local governments play a pivotal role in ensuring these recovery efforts are effectively planned, managed, coordinated and include measures for reducing disaster risks.

Following crises such as disasters and conflicts, rebuilding work should adopt practices that:

- Promote a decentralised and participatory approach to reconstruction;
- Make best use of local skills, institutions and resources in order to build back better;
- Include disaster risk assessments and decentralised disaster risk; reduction into reconstruction processes to lessen vulnerability to future risks;
- Promote the recovery of market systems that will build back local livelihoods; and
- Enable a more cost-effective and sustainable recovery.

9.3.2 Utilising urban missions as implementation tool for DRR

At present, India hosts a number of schemes for the comprehensive development of urban areas. These schemes should be targeted and aligned with CDMPs for DRR activities. Schemes like Smart Cities, AMRUT, JNNURM, UIDSSMT, NERUDP, NUIS, Swachh Bharat Mission, Metro Projects, etc. should be targeted and planned for the city through risk sensitive planning approach. DRR measures should be reinforced in all the planned activities of the development of urban area.

9.3.3 Implementing new technologies

Technical innovations and advancement have led to drastic changes in conventional planning methodologies and techniques. The following new methods can be used for planning:

- GIS
- Remote Sensing
- Aerial photography
- GPS
- Online/offline applications

Box 8

Smart Cities

In the approach to the Smart Cities Mission, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'smart' solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas and create a replicable model which will act like a light house to other aspiring cities. The Smart Cities Mission of the Government is a bold, new initiative. It is meant to set examples that can be replicated both within and outside the Smart City, catalysing the creation of similar Smart Cities in various regions and parts of the country.

The core infrastructure elements in a Smart City include:

- Adequate water supply
- Assured electricity supply
- Sanitation, including solid waste management
- Efficient urban mobility and public transport
- Affordable housing, especially for the poor
- Robust IT connectivity and digitalisation
- Good governance, especially e-governance and citizen participation
- Sustainable environment
- Safety and security of citizens, particularly women, children and the elderly
- Health and education

At the planning stage of Smart City elements, DRR features should be integrated in the different activities.

- Database at international, national, state and local level (E.g., Big data, EMDAT, etc.)
- Geotagging
- Crowdsourcing data
- Online surveys
- Social media
- Mobile-based services
- Geotagging of houses and other buildings
- Deployment of drones for live monitoring

Big Data Science

The growing emphasis on increasing resilience has occurred roughly at the same time as the emergence, since the end of the 2000s, of 'Big Data', which is

conceptualised as an ecosystem made up of three factors: digital data from sources as diverse as satellites and mobile phones, the capacity to analyse and use that data, and the people who produce, analyse, and/or use the data. Big Data has opened up promising approaches to disaster resilience. Mobile phone data, for example, can provide an incredibly detailed view of population behaviour and movement in areas that were previously observed infrequently and indirectly. Social networks like Twitter are already improving the ability of humanitarian and DRR organisations to monitor and respond to hazards. Further, increasing mobile phone penetration and access to internet, in developing countries are creating new opportunities to gather Big Data. Over the next decade, there is likely to be an explosion of new data.

Examples of sources of Big Data are:

Types	Examples	Opportunities
Category 1: Exhaust Data		
Mobile-Based	Call Details Records(CDRs) GPS(Fleet tracking, Bus AVL)	Estimate population distribution and socioeconomic status in place as diverse as the U.K. and Rwanda
Financial transactions	Electronic ID E-license(e.g. insurance) Transportation cards(including airplane fidelity cards) Credit/debit cards	Provide critical information on population movements and behavioral response after a disaster
Transportation	GPS(Fleet tracking, Bus AVL) EZ passes	Provide early assessment of damage caused by hurricanes and earthquake
Online Traces	Cookies, IP Addresses	Mitigate impacts of infectious diseases through more timely monitoring using access logs from the online encyclopedia Wikipedia
Category 2: Digital Content		
Social media	Tweets(Twitter API) Check-ins (Foursquare) Facebook content	Provide early warning on threats ranging from disease outbreaks to food insecurity
Crowd-sourced/ online content	Mapping(Open street Map, Google Maps, help) Monitoring/ Reposting (uReport)	Empower volunteers to add ground-level data that are useful notably for verification purpose
Category 3: Sensing Data		
Physical	Smart meters Speed/ weight trackers USGS seismometers	Sensors have been used to assess the demand for using sensors to estimate demand for high efficiency cook-stoves at different price points in Uganda or willingness to pay for chlorine dispensers in Kenya
Remote	Satellite imagery(NASA TRMM, Landsat) Unmanned Aerial Vehicles(UAVs)	Satellite images revealing changes in , for example, soil quality or water availability have been used to inform agricultural interventions inn developing countries

9.4 Capacity Building

For effective risk sensitive planning, the capacity of city planners and decision makers needs to be built. A detailed Training Needs Assessment exercise should be carried out for the city to identify the exact requirements for capacity building. The training needs should be identified for personnel and organisational training and development.

The following suggested themes can be undertaken for capacity building for DRR across different sectors and hazards at different levels:

S.N.	Training Theme	Intended Level
1	Mainstreaming DRR into development planning	Policy makers, planners and programme/ project designers at the state and district levels
2	Mainstreaming DRR into rural development policies and programmes	Policy makers and programme/project designers at the state and district levels
3	Mainstreaming DRR into City Development Plans and their implementation strategies	Policy makers and programme/project designers at the state and city levels
4	Strengthening Panchayati Raj Institutions for mainstreaming DRR into development on the ground	Programme/project managers at the district and sub-district levels
5	Preparing health functionaries for emergency health services	Programme/project managers at the state and district levels
6	Creating a culture of safety and resilience through knowledge, innovation and education	Trainers and teachers at the district and sub-district levels
7	Strengthening emergency communication including early warning and last mile connectivity	Programme/project managers at the district and sub-district levels
8	Community Led Hazard Risk Vulnerability and Capacity (CLHRVC) assessment	Civil society functionaries; CBO members; programme/project managers at the district and sub-district levels
9	Participatory training and capacity needs assessment (PTCNA)	Trainers and training planners and managers at HIDMCC, AATI and other similar institutes, DMC, SIRDs and other sector level training institutions
10	Participatory evaluation and action learning (PEAL)	Programme/project managers at the state and district levels
11	Integrating gender approaches in DM plans and CCA plans	Programme/project designers and managers at the district and sub-district levels
12	Use of media in generating mass awareness on DM and CCA	Media and information officers from within government

Box 9

Model Building Bye Laws

Building Bye Laws are legal tools used to regulate coverage, height, building bulk, and architectural design and construction aspects of buildings so as to achieve orderly development of an area. They are mandatory in nature and serve to protect buildings against fire, earthquake, noise, structural failures and other hazards.

In India, there are still many small and medium sized towns which do not have building bye laws and in the absence of any regulatory mechanism, such towns are confronted with excessive coverage, encroachment and haphazard development resulting in chaotic conditions, inconvenience for the users, and disregard for building aesthetics, etc. The Town and Country Planning Organisation has made an effort to prepare Model Building Bye Laws - 2016 to guide State Governments, Urban Local Bodies, Urban Development Authorities, etc. These are an improvement over the previous Model Building Bye Laws brought out in 2004.

Source: http://www.indiaenvironmentportal.org.in/files/file/MODEL%20BUILDING%20BYE%20LAWS-2016.pdf

Box 10

Case: Surat's Resilience Journey: Appointing a Chief Resilience Officer

Surat is one of the fastest growing cities in the world, experiencing rapid industrialisation and migration. According to World Bank Sustainable Development Network, it's also one of the world's most climate change affected cities. In the past 100 years, Surat has experienced 23 floods, including a significant one in 2013, and an outbreak of the plague in 1994. The city's most pressing urban resilience priorities are: learning lessons from past events; building community and social resilience for early response to floods; preventing vector-borne diseases; and improving nutrition, water management and the electric grid.

Surat Municipal Corporation leaders have appointed a Chief Resilience Officer, under Surat's resilience building partnership with 100 Resilient Cities – pioneered by the Rockefeller Foundation. This new position was created to lead city-wide resilience building efforts to help Surat prepare for, withstand, and bounce back from the 'shocks' – catastrophic events like floods and storms – and 'stresses' – slow-moving disasters like acute traffic, air pollution, water shortages and social cohesion, which are increasingly part of 21st century life.

Source: http://www.100resilientcities.org/cities/entry/surats-resilience-challenge#/-_/

The training themes presented above are in alignment with the study carried out for preparing a long-term training and capacity building strategy for DRR in India under the National Cyclone Risk Mitigation Project (http://nidm.gov.in/ncrmp.asp). These themes can be further developed as required for the city.

10. Recommendations

For efficient implementation of provisions of building codes, town and country planning regulations and national guidelines for disaster management in the urban housing sector, the following recommendations should be considered:

Developing knowledge products: In most cities in India, there is limited information available to public. A comprehensive knowledge database should be developed for the city which contains research on local issues based on detailed assessments by experts and provides contextual information to people. This will encourage people to think about their environment and act accordingly to develop and safer living atmosphere.

Training of relevant staff: The staff responsible for sound functioning of city should be trained on a regular basis to build their capacity for addressing upcoming risk related issues. The staff should include engineers, architects, town planners, health experts, social mobilisers and other relevant staff members of urban local body.

Capacity building through training of construction contractors and workers: Resilient housing and infrastructure systems will not be implemented on the ground until the hands which construct them are well aware of the safe and resilient building practices and technologies. This requires for capacity building of construction contractors and workers to be well-trained in safer construction practices. With increased capacity, construction workers will get better working opportunities. This will increase the quality of built environment as well the living condition of the people working in the sector.

Showcasing appropriate technologies and building materials: The current building trends aspire for cement and concrete to be used as building materials, which can adversely affect the environment. Preference for these building materials has to be changed with demonstrated physical structures which portray strength and qualities of local building materials. Government and iconic buildings in the city should be encouraged to be built through local building materials. This will generate a sense of trust and pride among citizens and they will aspire for similar structures.

Awareness campaigns: Awareness campaigns on various themes related to safety and efficient management of city need to be initiated to engage and motivate the public to participate in activities aimed at making cities safer and resilient. Increased awareness will also lead citizens in making

right decisions and cooperating with city administration for sustainable development of the city.

Safety and quality audit: Regular audits and assessment help monitor trends of cities' safety measures. Safety and quality audits needs to be carried out at regular intervals to ensure the safe functioning of the city and highlight emerging discrepancies.

Penalties and incentives: For regulating laws and encouraging people to actively participate in building the city safely, penalties and incentives need to be imposed. Penalties will restrict the unregulated growth of the city and incentives will encourage the people to take safety friendly measures.

City legal instruments (policy and regulations): The knowledge products developed for the city should lead to formulation of policies and regulations to best suit the local needs for the holistic and safe development of the city. The context-specific measures should be promoted through policies and regulations to efficiently use local resources and capacities for the sound and development of resilient cities.

Conducting a detailed HRVA: A detailed HRVA should be carried out for the city. Emphasis should be given to identify city-specific hazards along with other hazards, which will help in prioritising actions and planning for DRR strategies.

Facilitating RVS: RVS should be done to identify, inventory, and screen buildings that are potentially seismically vulnerable. The RVS should be carried out in a phased manner to cater to large number of building in an urban area. Priority should be given to critical infrastructure, government buildings and older buildings. Unengineered buildings should be specifically assessed to find any concerns for building safety. After carrying out RVS, corrective actions should be planned and actions should be taken to make the building safe. This should be monitored through an online system by geotagging the buildings/infrastructure.

Retrofitting measures: Based on the recommendations from RVS, retrofitting measures should be planned and implemented for the infrastructure/building. The retrofitting measures should cater to hazards identified for the infrastructure/building like seismic, flood, cyclone, etc. The retrofitting measures should be planned based on the future development scenario and available resources. Building codes and zoning regulations should be strictly followed while doing a retrofitting exercise for a building.

11. Annexures

ANNEXURE 1: Format for conducting Rapid Visual Screening (RVS)

RVS Methodology - Masonry Buildings

The format for Seismic Zone IV is shown below:

Figure 14: RVS form for Masonry Buildings

IS 13935 : 2009

FORM 3

RAPID VISUAL SCREENING OF MASONRY BUILDINGS FOR SEISMIC HAZARDS

Seismic Zone IV Ordinary Building
(Also Seismic Zone III Important Building)

Photograph

Sketch Plan with Length and Breadth

1.1 Building Name: _____
1.2 Use: _____
1.3 Address: _____ Pin _____
1.4 Other Identifiers: _____
1.5 No. of Stories _____ **1.6** Year Built _____
1.7 Total Covered Area; all floors (sq.m) _____
1.8 Ground Coverage (Sq.m): _____
1.9 Soil Type: _____ **1.10** Foundation Type _____
1.11 Roof Type: _____ **1.12** Floor Type _____
1.13 Structural Components: _____
1.13.1 Wall Type: BB* ☐ Earthen ☐ UCR* ☐ CCB* ☐
1.13.2 Thickness of wall _____ **1.13.3** Slab thickness ___
1.13.4 Mortar Type: Mud ☐ Lime ☐ Cement ☐
1.13.5 Vert. R/F bars: Corners ☐ T-junctions ☐ Jambs ☐
1.13.6 Seismic bands: Plinth ☐ Lintel ☐ Eaves ☐ Gable ☐

*BB — Burnt Brick, *UCR — Uncoursed Random Rubble
*CCB: Cement Concrete Block

2.0 OCCUPANCY	3.0 SPECIAL HAZARD	4.0 FALLING HAZARD
2.1 ***Important buildings*:** Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences and Residences of Important Emergency person. **Any building having more than 100 Occupants may be treated as **Important**.* **2.2** ***Ordinary buildings*:** Other buildings having occupants <100	**3.1** High Water Table (within 5 m) and if sandy soil, then liquefiable site indicated. Yes No **3.2** Land Slide Prone Site Yes No **3.3** Severe Vertical Irregularity Yes No **3.4** Severe Plan Irregularity Yes No	**4.1** Chimneys **4.2** Parapets **4.3** Cladding **4.4** Others

RECOMMENDED ACTION:

- ☐ A, A+ or B: Evaluate in detail for need of reconstruction or possible retrofitting to achieve type C or D
- ☐ B+, C: Evaluate in detail for need for retrofitting
- ☐ If any Special Hazard 3.0 found, re-evaluate for possible prevention/retrofitting.
- ☐ If any of the falling hazard is present, either remove it or strengthen against falling.

Surveyor's sign: _____
Name: _____
Executive Engineer's Sign: _____
Date of Survey: _____

5.0 Probable Damageability in Few/Many Buildings

Building Type	5.1 Masonry Building			
Damage-ability in Zone III	A /A+	B/B+	C/C+	D
	G5/G4	G4/G3	G3/G2	G2

Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

While conducting an RVS of important buildings, the form relevant for a zone higher than its location should be used, i.e. for an important building in Zone III, the form for Seismic Zone IV should be used.

The surveyor has to fill out the following five sections and take photographs while carrying out the survey. Careful observation and recording of falling hazards is very important in Seismic Zones III, IV and V.

Section 1.0	Building characteristics covering building name, location and other identifiers followed by basic information on type of soil, area of building, types of building elements both in substructure (foundation) and superstructure (floors, walls, roofs) in terms of materials and presence or absence of earthquake resistant features such as vertical and horizontal reinforcement bars in walls
Section 2.0	Occupancy of the building: Importance of the building, its occupants and functions
Section 3.0	Special hazards including potential for liquefaction and landslides (at site level) and vertical and horizontal irregularities at the global building level
Section 4.0	Falling hazards are the elements which are not a part of the structural system of the building but which could collapse in earthquake shaking
Section 5.0	Probable damageability correlating different masonry typologies with probable levels of damage

RVS Methodology - Reinforced Concrete Structures

There is no single RVS methodology for reinforced concrete frame structures in the IS Codes. Different researchers in India have proposed methodologies (Sinha and Goyal, 2004; Mitra, 2010 and Arya, 2014).

The Arya (2014) RVS methodology is considered here as it is similar in layout and methodology to the RVS format for masonry buildings. It is applicable to reinforced concrete frame buildings with separate formats for different Seismic Zones and with the same considerations for Important Buildings. The format for Seismic Zone IV is given here. On filling up the form, the engineer can arrive at the anticipated Grade of Damageability of the building.

Figure 15: RVS form for RC/Steel Buildings

3 ***Rapid Visual Screening of RC/Steel Buildings for Seismic Hazards***

Seismic Zone IV Ordinary Building

(Also for Zone III Important Building)

Photograph

Sketch Plan with Length & Breadth

1.1 Building Name_____

1.2 Use_____

1.3 Address:_____

_____Pin _____

1.4 Other Identifiers_____

1.5 No. of Stories_____ **1.6** Year of Const._____

1.7 Storey Ht.: 1st _____, 2nd _____, 3rd _____ .etc.

1.8 Total Covered Area; all floors (sq.m) _____

1.9 Ground Coverage (Sq.m):_____

1.10 Soil Type:_____**1.11** Foundation Type:_____

1.12 Depth of Ground water table: _____

1.13 Bldg. Type: Frame ☐ Pre-cast ☐

Frame - Shear Wall ☐ Flat Slab Frame ☐

1.14 Thickness of infill wall: Exterior _____ Interior _____

1.15 Struct. Dwg./Calculations available: Yes / No (If yes,attach)

1.16 Extn. to the original bldg. Yes/ No (If.yes pl. indicate)

1.17 Location of Shear walls (if any)

1.18 Special Confining R/F in Beam/Column/joints:

1.19 Stair case: Separated ☐ Connected ☐ Enclosed ☐

2.0 OCCUPANCY

***2.1 Important buildings*:** Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person.

Any building having more than 100 Occupants may be treated as **Important.*

***2.2 Ordinary buildings*:-** Other buildings having occupants <100

3.0 SPECIAL HAZARD

3.1 High Water Table (within 5m) & if sandy soil, then liquefiable site indicated.
☐ Yes ☐ No

3.2 Land Slide Prone Site
☐ Yes ☐ No

3.3 Severe Vertical Irregularity
☐ Yes ☐ No

3.4 Severe Plan Irregularity
☐ Yes ☐ No

4.0 FALLING HAZARD

4.1 Chimneys ☐

4.2 Parapets ☐

4.3 Cladding ☐

4.4 Others ☐

RECOMMENDED ACTION:-

- ☐ C: evaluate in detail for need for retrofitting
- ☐ If any Special Hazard 3.0 found , re-evaluate for possible prevention/retrofitting.
- ☐ If any of the falling hazard is present, either remove it or strengthen against falling.
- ☐ URM infill : evaluate in detail for need of retrofitting

Surveyor's Sign :_____
Name:_____

Executive Engineer's Sign:_____

Date of Survey:_____

5.0 Probable Damageability in Few/Many Buildings

Building Type	5.1 RC or Steel Frame/ wooden Buildings				5.2 URM Infill
Damage-ability in Zone IV	C / C+	D	E,E+	F	
	G3 / G2	G2	-	-	G3

Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

Grades of Damageability of RCC Buildings

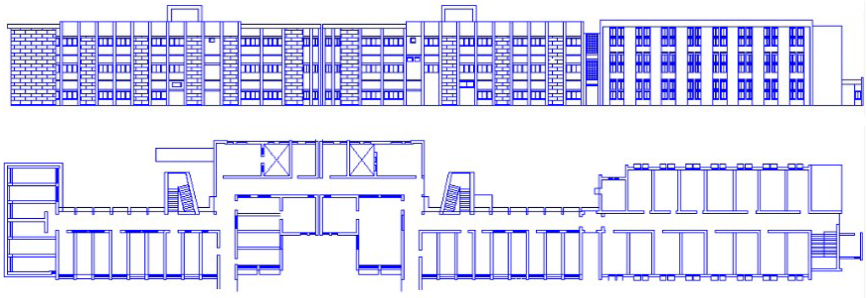
Grade 1: Negligible to slight damage(no structural damage, Slight non-structural damage) *Structural:* Nil *Non-Structural:* Fine Cracks in plaster over frame members or in walls at the base; Fine cracks in partitions & infills
Grade 2: Moderate damage(Slight structural damage, moderate non-structural damage) *Structural:* Cracks in columns & Beam of frames & in structural walls. *Non-Structural:* Cracks in partition & infill walls; fall of brittle cladding & Plaster, Falling mortar from joints of wall panels.
Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage) *Structural:* Cracks in columns & beam column joints of frames at the base& at joints of coupled walls. Spalling of concrete cover, buckling of reinforced rods. *Non-Structural:* Large cracks in partition & infill walls, failure of individual infill panels.
Grade 4: Very heavy damage(heavy structural damage, very heavy non-structural damage *Structural:* Large cracks in structural elements with compression failure of concrete & fracture of rebar's; bond failure of beam reinforcing bats; tilting of columns. Collapse of a few columns or single upper floor *Non-Structural:* Failure of loosely filled portion and infill wall panels.
Grade 5: Destruction (very heavy structural damage) *Structural:* Collapse of ground floor parts(e.g. Wings) of the building *Non-Structural:* Total destruction of non- Structural building components.

As with the form for masonry buildings, this form also is divided into five categories are shown in the table below:

Section 1.0	General information covering seismic zone, building name, use, address, other identifiers followed by basic information such as number of storeys, year of construction, type of soil, and area of the building. It also covers storey heights, covered area, soil, ground water and foundation details, and availability of drawings
Section 2.0	Occupancy of the building: Importance of the building, its occupants and functions
Section 3.0	Special hazards including potential for liquefaction and landslides (at site level) and vertical and horizontal irregularities in the building
Section 4.0	Non-structural or falling hazards
Section 5.0	Probable damageability correlating different typologies of reinforced concrete frame buildings with probable levels of damage in the respective shaking intensity

ANNEXURE 2: Case Study of A Masonry School Building Retrofit

The retrofitting of the Ludlow Castle School in New Delhi is considered one of the model school retrofit case studies in the country.



The school building was poorly maintained with many chajjas and shades falling off posing a real threat to the schoolchildren

The school building has three blocks separated by 25 mm wide expansion joints with a total plinth area of 4995 sq.m. It was constructed in three phases with the first two blocks in 1965 and the third one in 1978.The building is a load bearing unreinforced brick masonry building with reinforced concrete floor and roof slabs.

Original drawings were not available and had to be created. To understand the soil conditions, soil tests were carried out. The RVS analysis found geometric irregularities, deterioration of concrete, overstressed unreinforced masonry walls, and inadequate wall anchorage and shear transfer. Elastic analysis was carried out which indicated that the unreinforced masonry walls were overstressed. The building had been poorly maintained and may have posed a collapse hazard risk even during minor earthquakes.

The actual load of cupboards and other furniture in the school building was

evaluated for this analysis. The recommended retrofit scheme involved providing seismic belts as per the code provision IS 13935, connection of the walls and roof diaphragm, and reinforcement of the corners. As an important building in Seismic Zone IV, the Code recommends that it be considered for the next higher zone as below. (Extract from Code IS 13935)

Table 2: Building Categories (for use with IS 4326 & IS 13928)

Building Use	Building Category in Seismic Zone			
	II	III	IV	V
Ordinary	B	C	D	E
Important (I=1.5)	C	D	E	E

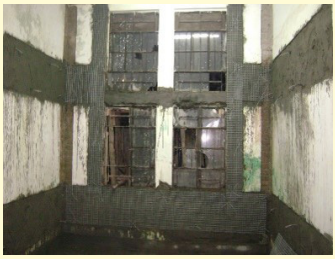
The school was retrofitted as per the guidance provided in the code, 'the overall lateral strength and stability of bearing wall buildings is very much improved, if the integral box like action of room enclosures is ensured. This can be achieved by providing horizontal bands. Strength of shear walls is achieved by providing vertical steel at selected locations such as the corners and T-junction of walls.'

A step by step pictorial representation of the retrofitting exercise in a classroom in the school is given below.

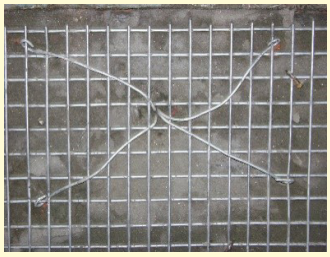
Stage by stage process of the retrofitting at the Ludlow Castle School, Rajnivas Marg, New Delhi by Delhi Public Works Department with technical support from GeoHazards International

1. Mark and cut groove for the seismic band with width as per prescriptive design mentioned in codes IS:13935 and IS:4326 and remove old plaster.

2. Drill holes through the walls to connect with band on the other side and insert four 3mm GI wire connectors and fix with heavy strength free flow non shrink grout.

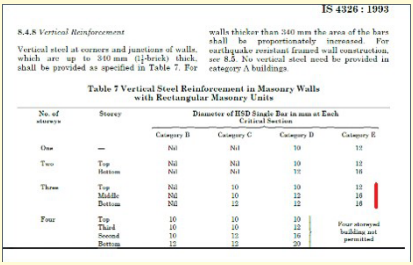


3. Apply first coat of plastering (1:3 coarse sand) of 15 mm thick in the exposed area and fix the 10 gauge GI weld mesh.



4. Tie the weld mesh with the inserted GI wire connectors. Similar process to be done around doors and ventilators to ensure continuity of band.

5. After fixing the weld mesh properly, apply the second coat of 12 mm thick plaster. Note that the corner reinforcing is not inserted as of now.



IS 4326 : 1993

8.4.8 *Vertical Reinforcement*

Vertical steel at corners and junctions of walls, which are up to 340 mm (1½-brick) thick, shall be provided as specified in Table 7. For walls thicker than 340 mm the area of the bars shall be proportionately increased. For earthquake resistant framed wall construction, see 8.5. No vertical steel need be provided in category A buildings.

Table 7 Vertical Steel Reinforcement in Masonry Walls with Rectangular Masonry Units

No. of storeys	Storey	Diameter of HSD Single Bar in mm at Each Critical Section			
		Category B	Category C	Category D	Category E
One	—	Nil	Nil	10	12
Two	Top	Nil	Nil	10	12
	Bottom	Nil	Nil	12	16
Three	Top	Nil	10	10	12
	Middle	Nil	10	12	16
	Bottom	Nil	12	12	16
Four	Top	10	10	10	Four storeyed building not permitted
	Third	10	10	12	
	Second	10	12	16	
	Bottom	12	12	20	

6. Extract from IS:4326 showing vertical reinforcement requirement (on the left) and precision drilling of floor slab to accommodate the 16mm vertical bar.

7. The single vertical reinforcement (11m long) is anchored to the corner as mentioned in the IS code and shuttering placed for concreting.

8. Micro concrete is then poured using heavy strength free flow non shrink grout with self-expansion greater than 20% as specified.

9. Similar process outside with sill, lintel bands in every classroom and vertical reinforcements in corners for the building to behave like a 'box' as mentioned in the code.

The Ludlow Castle School as it is in 2016

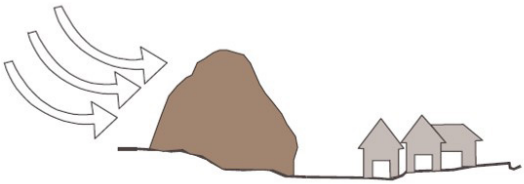
The Ludlow Castle School retrofit process is seen as a good example of complete coordination between the client (Department of Education represented by Principal, Ludlow Castle School), the Delhi Public Works Department (represented by the Superintending Engineer), and the Contractor (BBR India). The three stakeholders agreed on construction schedules such that none of the school activities were disrupted. The school site was handed over to the contractor by the school every working day an hour after school hours and they would work through late hours on the retrofitting. Cleaning the classrooms before handing over to the school every morning was included in the contract to ensure that the students and teachers were not inconvenienced. A good example where disruption planning helped in early completion of the project as well.

ANNEXURE 3: Retrofitting Measures for Hazards[3]

Wind shielding of building

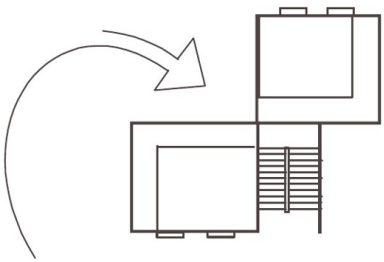
(a) No shielding from high wind due to absence of permeable/ solid barriers

(b) Shielding from high wind by permeable barriers such as trees

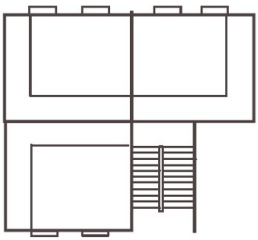


(c) Protection of house by hillock

Desirable plan for reducing cyclone damages



Asymmetric building with empty pockets are more vulnerable to damage



Symmetric buildings are more stable

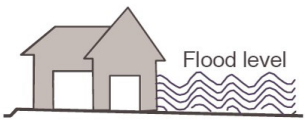
[3] *Wind Storms, Damage and Guidelines for Mitigative Measures, Dept. of Civil Engineering, IIT Roorkee. Weblink: http://www.iitk.ac.in/nicee/IITK-GSDMA/W03.pdf*

Group planning for reducing wind effects

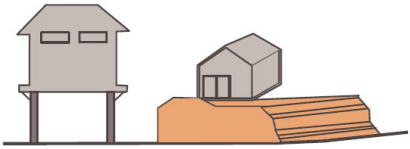
(a) Row planning creates wind tunnel effects resulting in higher wind forces

(b) Zig zag planning avoids wind tunnel effects

Construction on raised grounds/stilts to prevent inundation

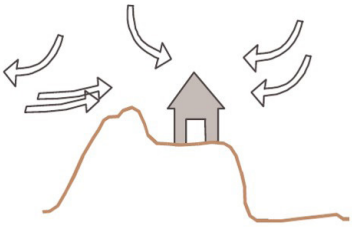


Construction at low level has risk of innundation

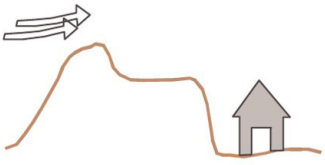


In case of non-availability of natural elevation construction of stills or artificially raised earth mound

Appropriate location of building in hilly terrains

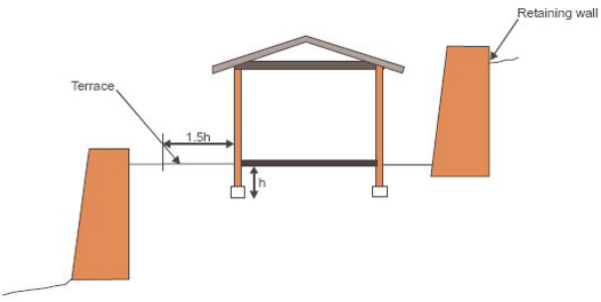


Building in ridge attracing high wind velocities

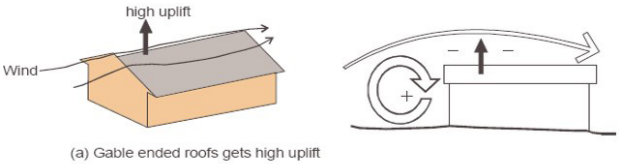


Building in vallies protected from high wind velocities

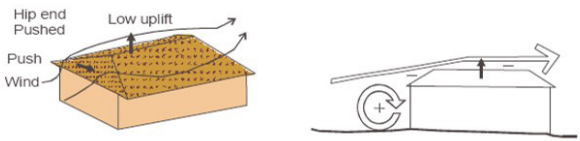
Recommended edge distance of foundations in hilly regions



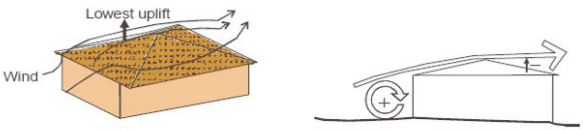
Effect of roof architecture on uplift



(a) Gable ended roofs gets high uplift

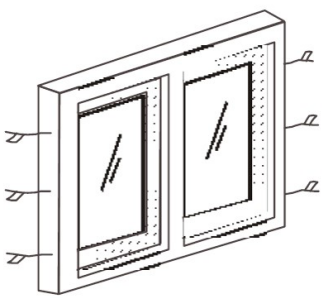


(b) Hip roofs gets lower uplift

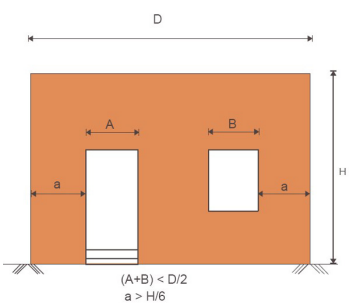


(c) Pyramidal roofs gets lowest uplift

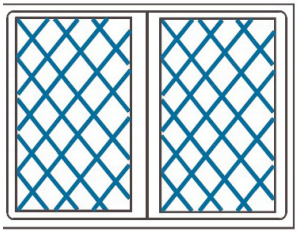
Adequate anchorage of door and window frames with holdfasts



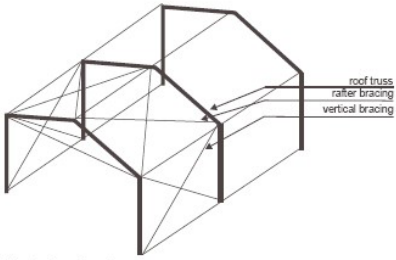
Manage wall openings in buildings to reduce damages due to cyclones



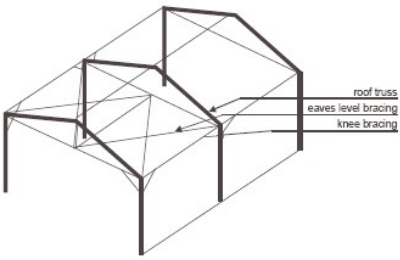
Protection of glass panes



Roof bracing for buildings

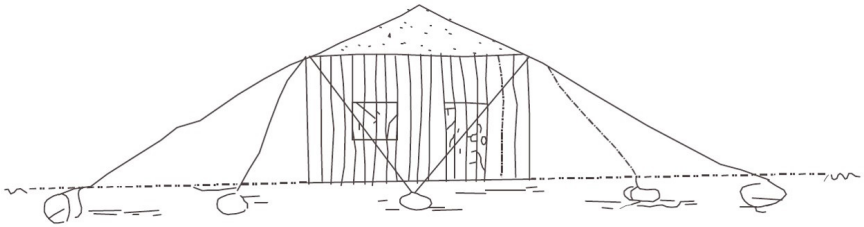


(a) Bracing in rafter plane

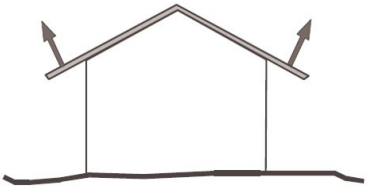


(b) Eaves level knee bracing

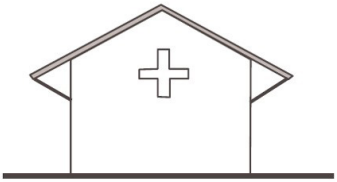
Rope tie-backs for non-engineered hutments



Proper tying of large overhangs

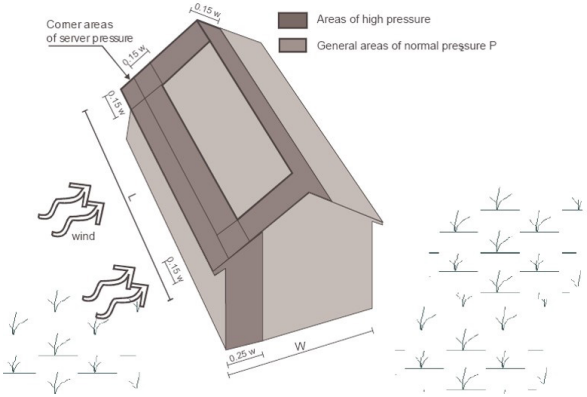


Large overhangs get lifted up and broken

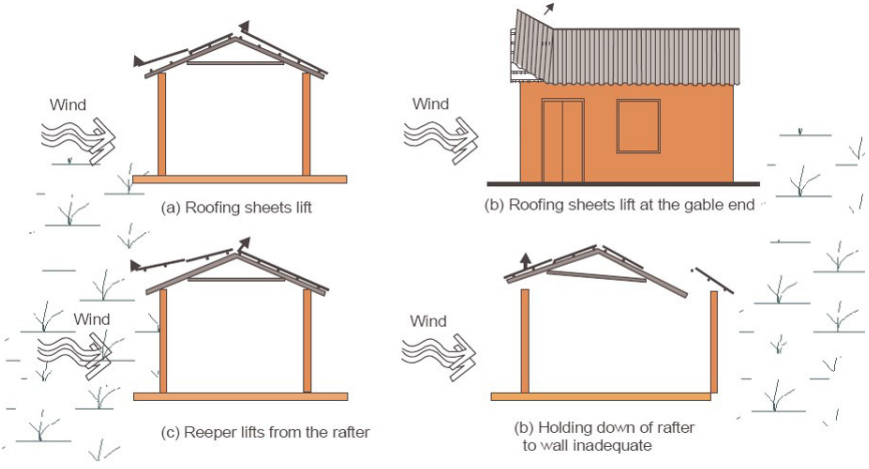


Avoid large overhangs > 450 mm, else use ties

Wind pressure areas on building faces



Types of roof damage due to wind



ANNEXURE 4: Useful Datasets for Conducting HRVA

INTERNATIONAL DATA SOURCES

Centre for Research on the Epidemiology of Disasters (CRED)

The Emergency Disasters Data Base (EM-DAT) managed by the Centre for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Louvain, Belgium is a publicly accessible international database collecting information on natural and technological disasters. The database contains approximately 15,700 entries with an average of 700 new entries per year and covers the period from 1900 to the present. It is updated on a daily basis and made available to the public once a month after validation of the figures. Criteria for inclusion in the database are as follows: ≥ 10 people killed, and/or ≥ 100 people reported affected, and/or a declaration of a state of emergency, and/or a call for international assistance. Events are entered on a country-level basis and information collected includes location, date, number of people killed/injured/affected, number homeless, and estimated damage costs. Sources include governments, UN agencies (UNEP, OCHA, WFP, and FAO), NGOs (IFRC), research institutions, insurance institutions (Lloyds) and press agencies, although priority is given to UN agencies. Amongst disaster databases, EM-DAT provides one of the most comprehensive and transparent explanations of the methodology employed. The database is searchable by country, disaster type, or timeframe. Due to the nature of the inclusion criteria, EM-DAT maintains a "global observation level and a national resolution level". This makes some smaller scale disasters "invisible" and creates difficulties for agencies attempting to disaggregate disasters at a local or municipal level.
[Accessed June 05, 2016: http://www.cred.be]

Münich Reinsurance Company: NatCat

NatCat is a private international level disaster database maintained by Munich Reinsurance Company. NatCat collects information on natural disasters (excluding technological disasters) and entries cover a period from 79AD to the present (although only major events are recorded prior to 1980). There are over 20,000 entries in the database with approximately 800 new entries per year, in part due to the lack of exclusion criteria enforced. Events are entered on a country and event level and recorded information includes number of people killed/injured/affected, economic losses, and scientific data such as wind speed, magnitude, and geocoding. Sources include national insurance agencies, Lloyds, press and media, UN agencies, NGOs, world weather services, clients and subsidiaries. Priority is given to clients and branches, and insurance industry reports. Due

to the availability of resources, NatCat is able to provide detailed economic loss data which is not always found in databases that rely on humanitarian agencies in the field. However, because of its dependence on calculating insured losses, it provides less data for areas with lower insurance coverage. The database is partially accessible to the public, although it requires the most recent internet operating systems to view the data, and more is only available to clients of Munich Re. The publicly available information includes a short report searchable by country, time-period, or event type (limited to earthquake, flood, volcanic eruption, storm, other) and provides georeferencing, but only provides information on a very limited number of natural disaster types. As it partially publicly accessible, it is not possible to report on any search functions of the database.
[Accessed June 05, 2016: https://www.munichre.com/corporate-responsibility/en/solutions/reinsurance/NATHAN/index.html]

Swiss Reinsurance Company: Sigma

Swiss Reinsurance Company maintains the Sigma database, a limited access global natural (excluding drought) and man-made disaster database. Events are recorded from 1970 to the present. There are approximately 7000 entries in the database with 300 new entries per year probably due to the more stringent inclusion criteria. Sigma requires at least one of the following for inclusion in the database; ≥20 deaths and/or, ≥50 injured and/or, ≥2000 homeless and/or, insured losses >US$14 million (Marine), >US$28 million (Aviation), >US$35 million (all other losses), and/or total losses in excess of US$70 million. Disasters are recorded on an event entry basis and recorded information includes dead, missing, injured, and homeless, along with detailed accounting of insured and uninsured damages. However, Sigma does not report "affected" nor does it clearly define the variables of homeless, causing an underreporting of human effects. Sources of information include newspapers, Lloyds, primary insurance and reinsurance periodicals, internal reports, and online databases although no primary source is suggested. Again, the lack of public accessibility to the Sigma database makes it difficult to report on the ability to search the database. However, Sigma does provide a yearly publication of "raw information" listing all disasters for the year.
[Accessed on June 05, 2016: http://www.swissre.com]

ADRC: GLIDE

The Global Disaster Identifier Number (GLIDE) is a project initiated and maintained by the Asian Disaster Reduction Center (ADRC) in collaboration with ISDR, CRED, UNDP, IFRC, FAO, World Bank, OFDA/USAID, LA Red, and OCHA/

ReliefWeb. A GLIDE number is generated for all disaster events with the aim being that the number is then attached to all databases documenting the same disaster thereby linking the various information sources. The GLIDE database is searchable by date, disaster type, country, and GLIDE number. Information produced by a search includes date, duration of event, location, magnitude, information source used, and a description of the event which will include human and economic loss information where available.
[Accessed June 05, 2016: http://www.glidenumber.net/glide/public/search/search.jsp]

BASICS

The British Association for Immediate Care (BASICS), a U.K. based charity, maintains a database of natural and technological disasters. The database contains approximately 7500 records dating back to the Mount Vesuvius eruption in 79AD. The database is searchable by two methods. By accessing the following URL http://www.basedn.freeserve.co.uk/ it is possible to search by type of disaster only. Information on disaster type, date, location, number of people dead/injured, and additional comments are listed although the completeness of the records varies between disasters. It is also possible to access the website via another URL on an associated webpage: http://www.basics.org.uk/data/searchPage.php. It is possible to search by date, country, and/or casualties or incident type freely entered. However, the information provided only includes the incident, the number dead, and the additional comments. There is no methodology provided to suggest sources of information or inclusion criteria and the different search options are slightly confusing.

Asian Disaster Reduction Center (ADRC)

ADRC maintains a database of Disaster Information for Member Countries, which provides information about natural disasters in Asia and Southeast Asia. Information is available in English and Japanese and the database is searchable by member country with entries beginning in 1998 and continuing to the present. Events are listed in chronological order and therefore easily searchable if an exact date of the event is known. It is not clear from the website what the criteria for inclusion are as there are few entries listed for each country. Disaster entries include the GLIDE number, location of event, date/duration, number dead, and injured, evacuated, and material damages as reported by contributing sources. Sources include UN agencies (OCHA), Reuters and international news agencies (AFP, BBC, CNN), and NGOs (IFRC, Catholic Relief Services).
[Accessed June 05, 2016: http://www.adrc.asia/view_disaster_en.php?NationCode=356&lang=&KEY=2100]

National Oceanic and Atmospheric Administration (NOAA)

NOAA is an agency that enriches life through science. Its reach goes from the surface of the sun to the depths of the ocean floor as they work to keep citizens informed of the changing environment around them. From daily weather forecasts, severe storm warnings, and climate monitoring to fisheries management, coastal restoration and supporting marine commerce, NOAA's products and services support economic vitality and affect more than one-third of America's gross domestic product. NOAA's dedicated scientists use cutting-edge research and high-tech instrumentation to provide citizens, planners, emergency managers and other decision makers with reliable information they need when they need it.
[Accessed June 05, 2016: http://www.noaa.gov/about-our-agency]

Federal Emergency Management Agency (FEMA)

The Federal Emergency Management Agency (FEMA) is an agency of the United States Department of Homeland Security. The agency's primary purpose is to coordinate the response to a disaster that has occurred in the United States and that overwhelms the resources of local and state authorities. The governor of the state in which the disaster occurs must declare a state of emergency and formally request from the president that FEMA and the federal government respond to the disaster. While on-the-ground support of disaster recovery efforts is a major part of FEMA's charter, the agency provides state and local governments with experts in specialized fields and funding for rebuilding efforts and relief funds for infrastructure by directing individuals to access low interest loans, in conjunction with the Small Business Administration. In addition to this, FEMA provides funds for training of response personnel throughout the United States and its territories as part of the agency's preparedness effort.
[Accessed June 05, 2016: https://www.fema.gov/about-agency]

DOMESTIC DATA SOURCES

ISRO/Bhuvan

Apart from visualisation, Bhuvan provides timely disaster support services (domestic and international), free satellite data and product download facility, and rich thematic datasets. Bhuvan uses a crowdsourcing approach to enrich its maps and collect point of interest data. It also acts as a platform for hosting government data (example - Karnataka Forest Department datasets). Some of the data that can be downloaded from Bhuvan are satellite data (up to 25m resolution LISS-III data) and products (like NDVI, OHC datasets, Cartosat Digital Elevation Model etc.)
[Accessed June 05, 2016: http://bhuvan.nrsc.gov.in/bhuvan_links.php]

Geological Survey of India (GSI)

GSI provides various reports on geological exploration of various parts of the country. GSI carries out various studies across the country and provides the reports through their portal. Some of the studies include: Surface Mapping, Geological Mapping, Airborne Geophysical Surveys, Ground Geophysical Surveys, Offshore Survey And Exploration, Mineral and Energy Resources Exploration, Mineral (Non-Coal) Exploration, Coal And Lignite Exploration, Engineering Geology And Geotechnical Investigations, Glaciological Studies, Geoenvironmental Studies, Geoseismology and Seismotectonic Studies.
[Accessed June 05, 2016: http://www.portal.gsi.gov.in]

Open Government Data Platform India

Government of India through its Open Government Data Platform (data.gov.in) publishes and makes available data from various departments for public use.
[Accessed June 05, 2016: https://data.gov.in/catalog/year-wise-damage-caused-due-floods-cyclonic-storm-landslides-etc]

India Meteorological Department (IMD)

IMD provides data on daily meteorological conditions as well as historic data. The historic data can be procured from IMD's data management centre, Indian Institute of Tropical Meteorology (IITM: http://www.tropmet.res.in/) located in Pune.
[Accessed June 05, 2016: http://imd.gov.in/]

Central Water Commission (CWC)

CWC is an apex body to monitor all the surface water bodies in the countries, including the reservoirs. Water discharge data, levels of various dams, etc. are provided by CWC.
[Accessed on June 05, 2016: http://www.cwc.nic.in/]

ANNEXURE 5: Flood Risk Assessment as an Example of Hazard Analysis

Flood Risk Assessment

Objective - Flood Risk Assessment will include estimation of flood risk based on damages caused and losses incurred from a flood event in a particular area and its impact of socio-economic condition of the population.

The Flood Risk Assessment will include analysis of the following components:

- Precipitation - Spatial and temporal distribution of precipitation, volume of precipitation
- Water Catchment Area - Slope inclination, shape and size of catchment area
- Soil Type - Infiltration and absorption capacity
- Ground Cover- Crop and vegetation, forestry
- Drainage pattern- Natural drainage pattern, canals

Various approaches can be adopted towards Flood Hazard Assessment and Flood Risk Mapping:

- **Geomorphological Approach:** This approach is more suited to relatively uncontrolled or virgin natural river basins. This approach helps in qualitative assessment of flood hazards. However, the maps generated through this approach may not be reliable if embankments are present and raised markedly.

- **Historical Approach:** This approach mainly refers to the major flood marks which appear as silt deposits on sloping river banks and trees, erosion traces on banks and around trees and discoloration of structures. Information is also obtained from interviews/ literature and compared with the elevations of the high-water marks. It also includes study of various soil types. Through this approach, flood inundation maps can be prepared; the historical inundation data is used for calibrating the inundation model.

- **Damage Approach:** It determines the flood damage distribution in flood prone areas by using damage data and inundation data.

- **Remote Sensing Data Based Approach:** It can provide information on flood inundated areas for different magnitudes of floods so that the extent of flooding can be related to the flood magnitude or flood stages of the river. Inundation extent for specific flood return periods may also be estimated.

- **Hydrological-Hydraulic Approach**: Hydrological and hydraulic models are used to simulate quantitatively the depth, area and duration of inundation in a flood. Maps based on this approach not only show inundation profile but may also be used to evaluate the effects of flood control programmes such as river channel improvements, and flood water detention reservoirs, as well as urbanisation of the watershed etc.

While conducting flood risk assessment, the following must be ensured:
- Identify river basins within the state
- Delineate flood zones
- Identify districts, cities, and towns in these flood zones
- Identify downstream settlements from dams and reservoirs

Different types of flood maps can be generated:

Flood Inundation Map: Inundation maps are prepared during a flood event, when the flood water in the river overtops its banks and leads to the flooding of adjoining areas or flood plains.

Flood Hazard Map: A flood hazard map provides information about the return period associated with the areal extent of inundation for a reach of a river.

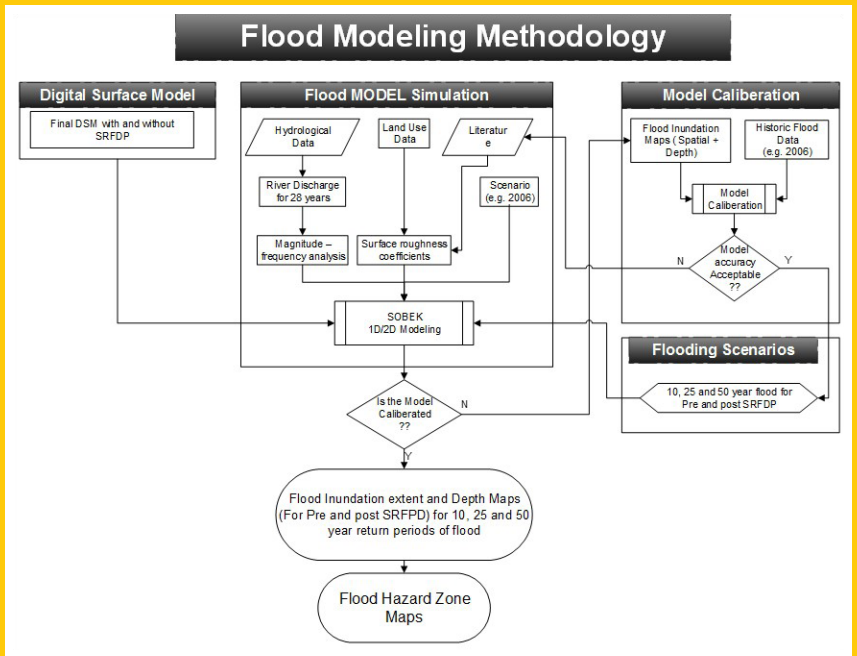
Flood Risk Zone Map: A flood risk zone map provides information about the risk associated with the damages caused or losses resulting from a flood event in a particular area or flood risk zone.

Flood Plain Zoning Map: Flood plain zoning map categorises various flood zones based on administrative legislations for planning and development of the flood plains for various purposes such as agricultural activities, sports areas, industrial areas and residential areas etc.

The schematic diagram given at Figure 14 shows the different types of flood maps that can be generated during flood risk assessment:

Types of data required for flood risk assessment and modelling:
- Data on elevation of the floodplain
- Floodplain and channel geometry: River centreline, banks, river cross sections
- Remote sensing data on land use
- Historical gauge-discharge data
- Historical inundation data
- Administrative maps

Figure 16: Conceptual diagram of flood hazard assessment using SOBEK software



Available software for Flood Hazard Risk Assessment and Modelling include:

- ERDAS, ILWIS, Arc-GIS (General GIS and Remote Sensing Software which could be used for data capturing and analysis)
- Mike 11, Mike 21, Mike Flood, SOBEK, Flow2D, HEC-RAS, HEC-GeoRAS /HEC HMS (Flood Modelling software)

To estimate the flood risk, flood hazard mapping should be followed by vulnerability analysis, which will detail the impact of the flood on infrastructure, environment and socio-economic condition of people living in the flood-affected areas.

New Urban Agenda: Disaster Risk Reduction

India has welcomed the adoption of the Habitat III New Urban Agenda (20-year global blueprint adopted by United Nations Conference) as a significant contribution to focussing attention on the risks of rapid urbanisation and the

importance of taking concrete measures to build cities in a way that reduces exposure to disasters and improves the quality of life for urban dwellers. Among other components, it calls for exploring and developing feasible solutions for climate and disaster risks in cities and human settlements. The New Urban Agenda is a very important element of the 2030 Sustainable Development Agenda which commenced with the adoption of the Sendai Framework for Disaster Risk Reduction, 2015. It also envisions equal rights, the right to adequate housing and fundamental freedoms, along with functional social and civic systems, with participatory access. The key components of India's New Urban Agenda are long-term, integrated urban planning, design, sustainable financing frameworks and the cooperation of all levels of government, with the participation of civil society and stakeholders, we have also recognised the importance of managing urban areas as one of the great challenges of the 21st century when it launched the Making Cities Resilient Campaign in 2009, further the implementation of New Urban Agenda will support the achievement of the Sustainable Development Goals and the Sendai Framework targets on reducing disaster losses. Considering the aforesaid targets, the present handbook on Disaster Risk Reduction (by UNDP, BMTPC) is intended for urban managers and local bodies who have very important role in formulation and implementation of various housing schemes in their respective urban local bodies. The expected benefits of the present handbook will lead to minimizing hazard specific impacts and vulnerabilities in urban centres located in different climatic zones of India.

ANNEXURE 6: Milestones in Disaster Management in India

National Disaster Management Plan 2016

The National Disaster Management Plan (NDMP) provides a framework and direction to the government agencies for all phases of disaster management cycle. The NDMP is a dynamic document, in the sense that it will be periodically improved in alignment with the emerging global best practices and knowledge base in disaster management.

Weblink:http://www.ndma.gov.in/images/policyplan/dmplan/National%20Disaster%20Management%20Plan%20May%202016.pdf

Model Building Bye Laws - 2016

Building Bye Laws are legal tools used to regulate coverage, height, building bulk, and architectural design and construction aspects of buildings so as to achieve orderly development of an area. In India, there are still many small and medium sized towns which do not have building bye-laws and in the absence of any regulatory mechanism, such towns are confronted with excessive coverage, encroachment and haphazard development resulting in chaotic conditions, inconvenience for the users, and disregard for building aesthetics, etc. Town and Country Planning Organisation (TCPO) has prepared Model Building Bye Laws - 2016 to guide State Governments, Urban Local Bodies, Urban Development Authorities, etc.

Weblink:http://www.indiaenvironmentportal.org.in/files/file/MODEL%20BUILDING%20BYE%20LAWS-2016.pdf

New Urban Agenda, Quito Declaration on Sustainable Cities and Human Settlements for All 2016

This century will see a substantial majority of the world's population living in urban centers. The adoption of a New Urban Agenda—an action-oriented document will set global standards of achievement in sustainable urban development, rethinking the way we build, manage, and live in cities through drawing together cooperation with committed partners, relevant stakeholders, and urban actors at all levels of government as well as the private sector.

Weblink: https://habitat3.org/the-new-urban-agenda
https://www2.habitat3.org/bitcache/99d99fbd0824de50214e99f864459d8081a9be00?vid=591155&disposition=inline&op=view

Paris Agreement 2015

At the Conference of Parties (COP) 21 held in 2015, parties to the United

Nations Framework Convention on Climate Change (UNFCC) signed the Paris Agreement, which aims to combat climate change and accelerate and intensify the actions and investments needed for a sustainable low carbon future.
Weblink: https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

Sustainable Development Goals 2015

The Sustainable Development Goals (SDGs) build on the success of the Millennium Development Goals (MDGs) and aim to go further to end all forms of poverty. The new Goals are unique in that they call for action by all countries, poor, rich and middle-income to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and addresses a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection. National governments are expected to take ownership and establish national frameworks for the achievement of the 17 SDGs.
Weblink:http://www.un.org/sustainabledevelopment/sustainable-development-goals/

Launch of AMRUT, Smart Cities Mission and Housing for All (Urban) 2015

Three major urban development initiatives were launched in June 2015 aiming at formulation of development visions and implementation of developmental activities for the cities in India.
Weblink:
AMRUT: http://amrut.gov.in/
Smart Cities: http://smartcities.gov.in/
Housing for All (Urban): http://mhupa.gov.in/User_Panel/UserView.aspx?TypeID=1434

Sendai Framework for Disaster Risk Reduction 2015

The Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) is the first major agreement of the post-2015 development agenda, with seven targets and four priorities for action. The SFDRR recognizes that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders.
Weblink: http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

National Policy on Disaster Management 2009

The National Policy on Disaster Management will provide the framework/ roadmap for handling disasters in a holistic manner. It has been prepared in tune with and in pursuance of the Disaster Management Act, 2005. The Policy has a vision to build a safe and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response. The Policy covers all aspects of disaster management covering institutional, legal and financial arrangements; disaster prevention, mitigation and preparedness, techno-legal regime; response, relief and rehabilitation; reconstruction and recovery; capacity development; knowledge management and research and development.
Weblink: http://www.ndma.gov.in/images/guidelines/national-dm-policy2009.pdf

National Disaster Management Act 2005

The Act lays down institutional, legal, financial and coordination mechanisms at the national, state, district and local levels for DM. It is mandated in the Act that the institutions are not parallel structures and will work in close harmony to usher in a paradigm shift in DM from a relief-centric approach to a proactive regime that lays greater emphasis on preparedness, prevention and mitigation.
Weblink: http://www.ndma.gov.in/images/ndma-pdf/DM_act2005.pdf

Glossary

Acceptable risk: The level of potential losses that a society or community considers acceptable given existing social, economic, political, cultural, technical and environmental conditions.

Biological hazard: Process or phenomenon of organic origin or conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

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

Capacity development: The process by which people, organisations and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through improvement of knowledge, skills, systems, and institutions.

Coping capacity: The ability of people, organisations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters.

Deterministic: Describing a process with an outcome that is always the same for a given set of inputs, i.e. the outcome is "determined" by the input. Deterministic contrasts with random, which describes a process with an outcome that can vary even though the inputs are the same. Deterministic analysis contrasts with probabilistic analysis.

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: The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.

Disaster risk management: The systematic process of using administrative directives, organisations, and operational skills and capacities to implement

strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster.

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.

Disaster risk reduction plan: A document prepared by an authority, sector, organisation or enterprise that sets out goals and specific objectives for reducing disaster risks together with related actions to accomplish these objectives.

Elements at risk: Population, buildings and engineering works, infrastructure, environmental features and economic activities in the area affected by a hazard.

Environmental risks: Risks to natural ecosystems or to the aesthetics, sustainability or amenity of the natural world.

Exposure People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.

Individual risk: The increment of risk imposed on a particular individual by the existence of a hazard. This increment of risk is an addition to the background risk to life, which the person would live with on a daily basis if the facility did not exist.

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.

Hazard footprint: The extent of a hazard shown on a map depicting the intensity and frequency of the hazardous event. Example of a flood hazard footprint is given in Figure 15.

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.

Figure 17 : Flood Hazard Footprint

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.

Population at risk: All those persons who would be directly exposed to the consequences of failure of a structure or facility if they did not evacuate.

Preparedness: Are the measures that ensure the organized mobilization of personnel, funds, equipment, and supplies within a safe environment for effective relief. Disaster preparedness is building up of capacities before a disaster situation prevails in order to reduce impacts. Its measures include inter alia, availability of food reserve, emergency reserve fund, seed reserve, health facilities, warning systems, logistical infrastructure, relief manual, and shelves of projects.

Probability: A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event.

There are two main interpretations:
i) Statistical - frequency or fraction – The outcome of a repetitive experiment of some kind like flipping coins. It includes also the idea of population variability. Such a number is called an "objective" or **relative frequentist** probability because it exists in the real world and is in principle measurable by doing the experiment.
ii) Subjective probability **(degree of belief)** – Quantified measure of belief, judgement, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgement regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes.

Probabilistic: A description of procedures, which are based on the application of the laws of probability. Contrasts with deterministic.

Residual risk: The remaining level of risk at anytime before, during and after risk mitigation measures have been taken. The risk that remains in unmanaged form, even when effective DRR measures are in place, and for which emergency response and recovery capacities must be maintained.

Response: is the set of activities implemented after the impact of a disaster in order to assess the needs, reduce the suffering, limit the spread and the consequences of the disaster, open the way to rehabilitation.

Reconstruction: the full resumption of socio-economic activities plus preventive measures.

Rehabilitation: is the restoration of basic social functions.

Risk: Risk = Hazard's potential worth of loss. This can be also expressed as "Probability of an event times the consequences if the event occurs".

Risk analysis: The use of available information to estimate the risk to individuals or populations, property or the environment, from hazards. Risk analyses generally contain the following steps: definition of scope, danger (threat) identification, estimation of probability of occurrence to estimate hazard, evaluation of the vulnerability of the element(s) at risk, consequence identification, and risk estimation. Consistent with the common dictionary definition of analysis, viz. "A detailed examination of anything complex made in order to understand its nature or to determine its essential features", risk analysis involves the disaggregation or decomposition of the system and sources of risk into their fundamental parts.

Qualitative risk analysis: An analysis which uses word form, descriptive or numeric rating scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur.

Quantitative risk analysis: An analysis based on numerical values of the probability, vulnerability and consequences, and resulting in a numerical value of the risk.

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.

Risk transfer: The process of formally or informally shifting the financial consequences of particular risks from one party to another whereby a household, community, enterprise or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party.

Societal risk: The risk of widespread or large scale detriment from the realisation of a defined risk, the implication being that the consequence would be on such a scale as to provoke a socio/political response.

Susceptibility: is exposure to danger.

Technological hazards: A hazard originating from technological or industrial conditions, including accidents, dangerous procedures, infrastructure failures or specific human activities, that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Tolerable risk: A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.

Uncertainty: Describes any situation without certainty, whether or not described by a probability distribution. Uncertainty is caused by natural variation and/or incomplete knowledge (lack of understanding or insufficient data). In the context

of structural safety, uncertainty can be attributed to (i) *aleatory uncertainty*: inherent variability in natural properties and events, and (ii) *epistemic uncertainty*: incomplete knowledge of parameters and the relationships between input and output values.

Vulnerability: The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Also, a set of conditions and processes resulting from physical, social, economic, and environmental factors, which increase the susceptibility of a community to the impact of hazards.

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Executive Director
Building Materials & Technology
Promotion Council
Core-5A, First Floor, India Habitat
Centre, Lodhi Road,
New Delhi-110003
Phone: +91-11-24636705, 2463
8096; Fax: +91-11-2464 2849
Email: info@bmtpc.org;
Website: www.bmtpc.org

Joint Secretary (Housing)
Ministry of Housing & Urban Poverty
Alleviation, Government of India
Room No.114-C,
Nirman Bhawan, New Delhi - 110011
Tel: 011-23061665;
Fax: 011-23061497
E-mail: jshousing-mupa@gov.in
Website: http://mhupa.gov.in

Country Director
UNDP India Country Office
United Nations Development
Programme (UNDP)
55 Lodhi Estate,
New Delhi - 110 003
Tel: 91 11 46532333,
Fax: 91 11 24627612
Email: info.in@undp.org
Website: www.in.undp.org