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NATIONAL DISASTER MANAGEMENT GUIDELINES

MANAGEMENT OF URBAN FLOODING

September 2010

NATIONAL DISASTER MANAGEMENT AUTHORITY
GOVERNMENT OF INDIA

National Disaster Management Guidelines

Management of Urban Flooding

National Disaster Management Guidelines: Management of Urban Flooding

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National Disaster Management Guidelines: Management of Urban Flooding has been formulated under the Chairmanship of Shri M. Shashidhar Reddy, MLA and Hon'ble Member, NDMA in consultation with various stakeholders, academic experts and specialists in the concerned subject and officials from the Ministries and Departments of Government of India and State Governments. Inputs were also received from US participants in the Indo-US workshop organised on January 7-9, 2009.

National Disaster Management Guidelines

Management of Urban Flooding

National Disaster Management Authority
Government of India

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Vice Chairman
National Disaster Management Authority
Government of India

FOREWORD

Urban flooding has been experienced over decades in India but sufficient attention was not given to specific efforts to deal with it. In the past, any strategy on flood disaster management largely focused on riverine floods affecting large extents of rural areas. Urban flooding is significantly different from rural flooding as urbanisation leads to developed catchments and in the event of heavy/ high intensity rainfall there is higher runoff which increases the flood peaks from 1.8 to 8 times and flood volumes up to 6 times. Consequently, flooding occurs very quickly due to faster flow times, sometimes in a matter of minutes. Taking this into account, NDMA has de-linked Urban Flooding from the subject of (riverine) Floods for the first time and commenced its efforts to come up with separate guidelines.

The National Guidelines for the Management of Urban Flooding have been formulated after a 'nine step' process taking on board, various Central Ministries, Departments, States and UTs and several Urban Local Bodies and Development Authorities. The process also included wide consultations with experts from scientific, technical and academic institutions and humanitarian organisations. The draft guidelines document was circulated to all the Ministries/ Departments at the Centre and the States/ UTs and ULBs for their feedback. All workable suggestions have been incorporated.

These guidelines will give a boost to the efforts for urban flood disaster management and strengthen the national vision of moving towards a more proactive pre-disaster preparedness and mitigation-centric approach. These contain all the details that are required by planners and implementers and will help in the preparation of plans by the Central Ministries/ Departments and the States/ UTs.

I am grateful to the members of the core group, steering committee and all others who contributed to this effort. Finally, I am pleased to place on record my sincere appreciation for Shri M. Shashidhar Reddy, MLA and Member, NDMA, who guided and coordinated the entire process of putting together this document which is looking at Urban Flooding in a holistic manner for the first time.

New Delhi
27 September 2010

General NC Vij
PVSM, UYSM, AVSM (Retd)

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Member
National Disaster Management Authority
Government of India

ACKNOWLEDGEMENTS

Evolving the National Guidelines for Management of Urban Flooding has been very challenging since this is the first ever document being put together on this subject in India, looking at Urban Flooding in a holistic manner. I am thankful to the members of the Core Group and Steering Committee for their efforts in helping NDMA in this task. I must place on record my very sincere appreciation of the untiring efforts made by Prof. Kapil Gupta, Department of Civil Engineering, Indian Institute of Technology Bombay and for his contribution, valuable inputs and feedback.

I would also like to express my sincere thanks to the representatives of various concerned central ministries and departments, experts from S&T and academic institutions, representatives from States/ UTs and urban local bodies, experts from national and state level institutions and all other key stakeholders for their valuable contributions that helped us to build the contents of the document. I would also like to place on record my appreciation for the contributions made by the US participants in the Indo-US Workshop held in Hyderabad in January 2009.

We have also referred to a large number of reports and technical documents, etc., from both within the country and outside, besides several websites, which have not been cited in the Guidelines. I wish to acknowledge all the inputs so derived.

I am also happy to acknowledge the support extended by my SRO Dr. Susanta Kumar Jena, my personal staff Mr. Srinivasulu Gunda, Mr. K. Ramprasad Babu and Mr. Ch. Gangadhar Rao during the various workshops and meetings and for all their assistance in the preparation of these Guidelines. I also wish to acknowledge the support extended by the NDMA Administration.

Finally, I would like to express my gratitude to General N.C. Vij, PVSM, UYSM, AVSM (Retd), Vice Chairman, NDMA for his valuable guidance and constructive criticism at various stages of the preparation of the Guidelines. I must also acknowledge my gratitude to the distinguished Members of the NDMA for their valuable insights and feedback.

New Delhi
27 September 2010

M. Shashidhar Reddy, MLA

Abbreviations

AICTE	All India Council for Technical Education
ALTM	Airborne Laser Terrain Mapping
APFM	Associated Programme on Flood Management
ARG	Automatic Rain Gauge
ASSOCHAM	Associated Chambers of Commerce & Industry
ATI	Administrative Training Institute
AUWSP	Accelerated Urban Water Supply Programme
AWS	Automatic Weather Station
BAUT	Boat Assault Universal Type
BMPs	Best Management Practices
BPL	Below Poverty Line
CBDM	Community-Based Disaster Management
CBOs	Community-Based Organisations
CCMNC	Cabinet Committee on Management of Natural Calamities
CCS	Cabinet Committee on Security
CDMP	City Disaster Management Plan
CDP	City Development Plan
CGWB	Central Ground Water Board
CII	Confederation of Indian Industry
CMG	Crisis Management Group
CPHEEO	Central Public Health and Environmental Engineering Organisation
CPWD	Central Public Works Department
CSR	Corporate Social Responsibility
DDC	Data Distribution Centre
DDMA	District Disaster Management Authority
DEM	Digital Elevation Model
DIT	Department of Information Technology
DRM	Disaster Risk Management
DSS	Decision Support System
DTM	Digital Terrain Model
DWR	Doppler Weather Radar

EIA	Environmental Impact Assessment
EMPs	Ecological Management Practices
EOC	Emergency Operation Centre
EWS	Early Warning System
FHM	Flood Hazard Mapping
FICCI	Federation of Indian Chambers of Commerce & Industry
FRA	Flood Risk Assessment
FRL	Full Reservoir Level
FTL	Full Tank Level
GIS	Geographic Information System
GPS	Global Positioning System
GWP	Global Water Partnership
HFL	High Flood Level
IC	Incident Commander
ICP	Incident Command Post
ICT	Information and Communication Technology
IDF	Intensity-Duration-Frequency
IDRN	India Disaster Response Network
IDSMT	Integrated Development of Small and Medium Towns
IIT	Indian Institute of Technology
IMG	Inter-Ministerial Group
IPCC	Inter-governmental Panel on Climate Change
IRC	Indian Roads Congress
IRS	Incident Response System
IRT	Incident Response Team
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
LID	Low Impact Development
LIDAR	Light Detection and Ranging
MA&UD	Municipal Administration and Urban Development
MCGM	Municipal Corporation of Greater Mumbai
MOHFW	Ministry of Health and Family Welfare
MSW	Municipal Solid Waste
MWL	Maximum Water Level
NASA	National Aeronautics and Space Administration

NATMO	National Thematic Mapping Organisation
NBC	National Building Code
NBSSLUP	National Bureau of Soil Survey and Land-use Planning
NCC	National Cadet Corps
NCCF	National Calamity Contingency Fund
NCMC	National Crisis Management Committee
NDC	National Data Centre
NDEM	National Database for Emergency Management
NER	North Eastern Region
NERUDP	North Eastern Region Urban Development Programme
NIC	National Informatics Centre
NISA	National Industrial Security Academy
NIT	National Institute of Technology
NLCP	National Lake Conservation Plan
NMHS	National Meteorological and Hydrological Services
NSS	National Social Service
NUIS	National Urban Information System
NWP	Numerical Weather Prediction
NYKS	Nehru Yuva Kendra Sangathana
PMF	Probable Maximum Flood
PWD	Public Works Department
QPE	Quantitative Precipitation Estimate
QPF	Quantitative Precipitation Forecast
RO	Responsible Officer
RWA	Resident Welfare Association
SDA	Slum Dwellers Association
SDI	Spatial Database Infrastructure
SEC	State Executive Committee
SHG	Self Help Group
SOP	Standard Operating Procedure
SPCB	State Pollution Control Board
SRSACs	State Remote Sensing Application Centres
SUDS	Sustainable Drainage Systems
SWAN	State Wide Area Network

TF	Task Force
UDA	Urban Development Authority
UDPFI	Urban Development Plan Formulation and Implementation
UFDM	Urban Flood Disaster Management
UFDMIS	Urban Flood Disaster Management Information System
UGC	University Grants Commission
UIDSSMT	Urban Infrastructure Development Scheme for Small and Medium Towns
ULB	Urban Local Body
UNDP	United Nations Development Programme
VG	Volunteer Group
VSAT	Very Small Aperture Terminal
WSUD	Water Sensitive Urban Design

Glossary of Terms

Backwater

Water level upstream from an obstruction which is deeper than it would normally be without the obstruction.

Best Management Practices

A structure or practice designed in stormwater management to prevent the discharge of one or more pollutants to the land surface thus minimising the chance of wash-off by stormwater. It can also be referred to a structure or practice to temporarily store or treat urban stormwater runoff to reduce flooding, remove pollutants, and provide other amenities (such as recreation, fishing spots, etc.).

Catchment

A topographically defined area, draining surface water to a single outlet point. It may frequently include an area of tributary streams and flow paths as well as the main stream.

Channel

The bed and banks of a stream or constructed drain that carries all flows.

Conveyance System

The drainage facilities, both natural and man-made, which collect, contain, and provide for the flow of surface and stormwater from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The man-made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.

Design Storm

A selected rainfall event of specified amount, intensity, duration and frequency used as the basis of design.

Detention Facility

An above or below ground facility, such as a pond or tank, that temporarily stores stormwater runoff and subsequently releases it at a slower rate than it is collected by the drainage facility system. There is little or no infiltration of stored stormwater.

Detention

The release of stormwater runoff from the site at a slower rate than it is collected by the stormwater facility system, the difference being held in temporary storage.

Drain

A buried pipe or other conduit (closed drain). A ditch (open drain) for carrying off surplus surface water or ground water. (To) Drain to provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or by internal flow. To lose water (from the soil) by percolation.

Drainage Basin

A geographic and hydrologic subunit of a watershed.

Drainage Channel

A drainage pathway with a well-defined bed and banks indicating frequent conveyance of surface and stormwater runoff.

Drainage Inlets

The receptors for surface water collected in ditches and gutters, which serve as a mechanism whereby surface water enters storm drains and this refers to all types of inlets (such as grate inlets, curb inlets, slotted inlets, etc.).

Embankment

A structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road.

Estuary

An area where fresh water meets salt water, or where the tide meets the river current (e.g., bays, mouths of rivers, salt marshes and lagoons). Estuaries serve as nurseries and spawning and feeding grounds for large groups of marine life and provide shelter and food for birds and wildlife.

Flood Zoning

Definition of areas, based on flood risk, within floodplain appropriate for different land uses

Floodplain Regulation

Laws defining acceptable use of land in defined areas, thus controlling the extent and type of future development

Floodplain

Area susceptible to inundation by a base flood including areas where drainage is or may be restricted by man-made structures which have been or may be covered partially or wholly by flood water from the base flood.

Groundwater Table

The free surface of the underground water that is frequently subjected to conditions such as fluctuating atmospheric pressure with the season, withdrawal rates and restoration rates. Therefore, the groundwater table is seldom static.

Hydraulics

The study of water flow; in particular the evaluation of flow parameters such as stage and velocity in a river or stream.

Hydrograph

A graph showing stage, flow, velocity, or other characteristics of water with respect to time. A stream hydrograph commonly shows rate of flow; a groundwater hydrograph shows the water level or head.

Hydrology

The science of the behaviour of water in the atmosphere, on the surface of the earth and within the soil and underlying rocks. This includes the relationship between rainfall, runoff, infiltration and evaporation.

Infiltration

The downward movement of water from the soil surface at ground level into the underlying subsoil. Water infiltrates into the soil profile and percolates through it. The infiltration capacity is expressed in terms of mm/hr. Infiltration

depends heavily on the vegetative cover of the soil surface, while permeability depends on the soil texture and compactness.

Inlet

A form of connection between the surface of a ground and a drain or sewer for the admission of surface and stormwater runoff.

Local Network

A network of Automatic Rain Gauges set by at a high density within urban areas.

Land Use Planning

Control and supervision of land use in floodplain (zoning, regulation, acquisition, relocation).

Major System

A system that provides overland relief for stormwater flows exceeding the capacity of the minor system and is composed of pathways that are provided, knowingly or unknowingly, for the runoff to flow to natural or man-made receiving channels such as streams, creeks or rivers.

Minor System

A system, which consists of the components of the storm drainage system that is normally designed to carry runoff from the more frequent storm events. These components include curbs, gutters, ditches, inlets, manholes, pipes and other conduits, open channels, pumps, detention basins, water quality control facilities, etc.

On-site and Off-site

On-site facilities are located on individual lots to enhance local stormwater retention/detention and interception of contaminants. Off-site facilities are located on stormwater networks to provide area-wide stormwater retention/detention and interception of contaminants.

Orography

The study of the physical geography of mountains and mountain ranges.

Rain Gardens

Rain gardens are part of the Low Impact Development (LID) paradigm for stormwater management. Rain gardens consist of a porous soil covered with a thin layer of mulch into which the stormwater runoff.

Rational Method

A means of computing storm drainage flow rates (Q) by use of the formula $Q = CIA$, where C is a coefficient describing the physical drainage area, I is the rainfall intensity and A is the area.

Recharge

Replenishment of groundwater by downward infiltration of water from rainfall, streams and other sources. Natural recharge occurs without assistance or enhancement by man. Artificial recharge occurs when the natural recharge pattern is modified deliberately to increase recharge.

Retention

The process of collecting and holding surface and stormwater runoff with no surface outflow.

Return Frequency

A statistical term for the average time of expected interval that an event of some kind

will equal or exceed given conditions (e.g., a stormwater flow that occurs every 2 years).

Runoff

The flow of water across the ground or an artificial surface generated by rain falling on it.

Sediment

Sediment is naturally-occurring material that is broken down by processes of weathering and erosion, and is subsequently transported by the action of fluids such as wind, water, or ice, and/or by the force of gravity acting on the particle itself.

Silt

A separate of soil consisting of particles between 0.002 and 0.02 mm in equivalent diameter.

Source Control

Non-structural or structural best management practices designed to minimise the generation of excessive stormwater runoff and/or pollution of stormwater at or near the source and protect receiving environments.

Stormwater

That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a stormwater drainage system into a defined surface water body, or a constructed infiltration facility.

Stormwater Drain

A particular storm drainage system component that receives runoff from inlets and conveys the runoff to some point. They are either closed conduits or open channels connecting two or more inlets.

Stormwater Drainage System

Constructed and natural features which function together as a system to collect, convey, channel, hold, inhibit, retain, detain, infiltrate, divert, treat or filter stormwater.

Stormwater Management

The process of controlling the quality and quantity of stormwater to protect the downstream environment.

Water Bodies

Waterways, wetlands, coastal marine areas and shallow groundwater aquifers.

Water Sensitive Urban Design

A design philosophy that provides a framework for managing water-related issues in urban areas. Water Sensitive Urban Design (WSUD) incorporates the sustainable management and integration of stormwater, wastewater and water supply into urban design. WSUD principles include incorporating water resource management issues early in the land use planning process. WSUD can be applied at the lot, street, neighbourhood, catchment and regional scale.

Watershed

A geographic region within which water drains into a particular river, stream, or body of water. The watershed may be composed of several sub-watersheds and catchments and/or sub-catchments.

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Executive Summary

Overview

As a part of its mandate, the National Disaster Management Authority (NDMA) has been making efforts to prepare guidelines for the management of different disasters and some cross-cutting themes. Even though urban flooding has been experienced over decades in India but sufficient attention was not given to plan specific efforts to deal with it. In the past, any strategy on flood disaster management largely focused on riverine floods affecting large extents of rural areas.

Mumbai floods of July 2005 turned out to be an eye-opener. Realizing that the causes of urban flooding are different and so also are the strategies to deal with them, NDMA has for the first time decided to address urban flooding as a separate disaster, delinking it from floods. NDMA commenced its efforts to formulate the Flood Guidelines in 2006 and released them in 2008. Even while the Flood Guidelines were under preparation, efforts commenced to formulate these Urban Flood Guidelines in August 2007.

Urban Flooding is Different

Urban flooding is significantly different from rural flooding as urbanisation leads to developed catchments which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, flooding occurs very quickly due to faster flow times, sometimes in a matter of minutes.

Urban areas are centres of economic activities with vital infrastructure which needs to be protected 24x7. In most of the cities, damage to vital infrastructure has a bearing not only locally but could even have global implications. They are also densely populated and people living in vulnerable areas, both rich and poor, suffer due to flooding. It has sometimes resulted in loss of life, damage to property and disruptions in transport and power, bringing life to a grinding halt, causing untold misery and hardships. Even the secondary effects of possible epidemics and exposure to infection takes further toll in terms of loss of livelihood, human suffering, and, in extreme cases, loss of life. Therefore, management of urban flooding has to be accorded top priority.

Increasing trend of urban flooding is a universal phenomenon and poses a great challenge to urban planners the world over. Problems associated with urban floods range from relatively localised incidents to major incidents, resulting in cities being inundated from a few hours to several days. Therefore, the impact can also be widespread, including temporary relocation of people, damage to civic amenities, deterioration of water quality and risk of epidemics.

Urban Flood Risk in India

There has been an increasing trend of urban flood disasters in India over the past several years whereby major cities in India have been severely affected. The most notable amongst them are Hyderabad in 2000,

Ahmedabad in 2001, Delhi in 2002 and 2003, Chennai in 2004, Mumbai in 2005, Surat in 2006, Kolkata in 2007, Jamshedpur in 2008, Delhi in 2009 and Guwahati and Delhi in 2010.

A special feature in India is that we have heavy rainfall during monsoons. There are other weather systems also that bring in a lot of rain. Storm surges can also affect coastal cities/ towns. Sudden release or failure to release water from dams can also have severe impact. In addition, the urban heat island effect has resulted in an increase in rainfall over urban areas. Global climate change is resulting in changed weather patterns and increased episodes of high intensity rainfall events occurring in shorter periods of time. Then the threat of sea-level rise is also looming large, threatening all the coastal cities. Cities/towns located on the coast, on river banks, upstream/ downstream of dams, inland cities and in hilly areas can all be affected.

Issues in Urban Flooding

Among the important cities of India, the average annual rainfall varies from 2932 mm in Goa and 2401 mm in Mumbai on the higher side, to 669 mm in Jaipur on the lower side. The rainfall pattern and temporal duration is almost similar in all these cities, which receive the maximum rainfall from the south-west monsoons. The average rainfall for the month of July in Mumbai is 868 mm and this far exceeds the annual average rainfall of 611 mm in London.

Stormwater drainage systems in the past were designed for rainfall intensity of 12 - 20 mm. These capacities have been getting very easily overwhelmed whenever rainfall of higher intensity has been experienced. Further, the systems very often do not work to the designed capacities because of very poor maintenance.

Encroachments are also a major problem in many cities and towns. Natural streams and watercourses have formed over thousands of years due to the forces of flowing water in the respective watersheds. Habitations started growing into towns and cities alongside rivers and watercourses. As a result of this, the flow of water has increased in proportion to the urbanization of the watersheds. Ideally, the natural drains should have been widened (similar to road widening for increased traffic) to accommodate the higher flows of stormwater. But on the contrary, there have been large scale encroachments on the natural drains and the river flood plains. Consequently the capacity of the natural drains has decreased, resulting in flooding.

Improper disposal of solid waste, including domestic, commercial and industrial waste and dumping of construction debris into the drains also contributes significantly to reducing their capacities. It is imperative to take better operations and maintenance actions.

Role of Science and Technology

The management of urban flooding is an emerging subject, and as such it has to be treated holistically in a multi-disciplinary manner. There are many issues that need to be considered in order to develop sound, reliable and most representative urban flood/disaster management strategies. A significant part of this management framework is dependent upon the use of science and technology for improved monitoring, modeling/ forecasting and decision-support systems. One way of improving the preparedness for urban

flooding is by setting up a vulnerability-based geospatial framework to generate and analyse different scenarios. This will help in identifying and planning for the most effective/ appropriate actions in a dynamic way to incorporate day-to-day changes that take place in urban areas, having the potential to alter the prevailing vulnerability profile.

Structure of Guidelines

These guidelines are an important step towards the development of plans for the management of urban flooding. These have been prepared to provide guidance to ministries/ departments, States/UTs and urban local bodies for the preparation of their Disaster Management (DM) plans. These guidelines call for a proactive, participatory, well-structured, fail-safe, multi-disciplinary and multi-sector approach at various levels.

The guidelines are presented in 10 chapters as detailed below:

Chapter 1 provides an introductory review about how urban flooding is different from riverine flooding, factors contributing to urban flooding, different weather systems in India, variability of rainfall, different city scenarios and genesis of the Guidelines.

Chapter 2 provides present status of the institutional framework at the national, state and the local levels, role of central ministries and departments, states and urban local bodies and other local authorities/organisations.

Chapter 3 discusses present status of flood forecasting, warning and communication system. The gaps are identified and recommendations have been made for enhancing capabilities, using state-of-the-art equipment.

Chapter 4 reviews the existing international and national status, practices for the design and maintenance of urban drainage systems. Gaps have been identified and recommendations made to develop efficient drainage systems with improved operations and maintenance actions.

Chapter 5 covers urban flood risk management issues, vulnerability analysis, risk assessment and hazard mapping, damage assessment and data generation options, etc.

Chapter 6 looks at town planning concepts, central and state legislations and a gist of relevant provisions under layout approvals and building permissions.

Chapter 7 deals with response actions including putting in place an incident response system.

Chapter 8 deals with capacity development at institutional and community levels, awareness generation and the role of different stakeholders and the need for proper documentation of events and actions.

Chapter 9 deals with implementation stategies, mainstreaming of DM into development planning, role of nodal ministry, mobilization of financial resources and implementation methodology, etc.

Chapter 10 provides the chapter-wise summary of action points.

Gist of Some of the Key Action Points

1. Ministry of Urban Development will be the Nodal Ministry for Urban Flooding
2. Establishment of the Urban Flooding Cell in Ministry of Urban Development (MoUD), State Nodal Departments and ULBs
3. Establishing a Technical Umbrella for Urban Flood Forecasting and Warning both at the National Level and State/UT levels
4. IMD will establish a 'Local Network Cell'
5. Establishment of Local Network of Automatic Rainfall Gauges (ARGs) for Real-time Monitoring with a density of 1 in every 4 sq km in all 2325 Class I, II and III cities and towns
6. Strategic Expansion of Doppler Weather Radar Network in the country to cover all Urban Areas for enhanced Local-Scale Forecasting Capabilities with maximum possible Lead-time
7. India Meteorological Department (IMD) will develop a Protocol for Sub-Division of Urban Areas on the basis of Watershed and issue Rainfall Forecast on the Watershed-basis
8. Establishing Urban Flood Early Warning System
9. Catchment will be the basis for Design of Stormwater Drainage System
10. Watershed will be the basis for all Urban Flooding Disaster Management Actions
11. All 2325 Class I, II and III cities and towns will be mapped on the GIS platform
12. Contour Mapping will be prepared at 0.2 - 0.5 m contour interval
13. Inventory of the existing stormwater drainage system will be prepared on a GIS platform
14. Future Stormwater Drainage Systems will be designed with a Runoff Coefficient of up to 0.95 in using Rational Method taking into account the Approved Land-use Pattern
15. Pre-Monsoon De-silting of Drains will be completed before March 31 every year
16. Involve the Residents' Welfare Associations (RWAs) and Community Based Organisations (CBOs) in monitoring this and in all Urban Flood Disaster Management (UFDM) actions
17. Every building shall have Rainwater Harvesting as an integral component of the building utility
18. Encroachments on Drains and in Floodplains will be removed by providing alternative accommodation to the poor people
19. Better Compliance of the Techno-legal Regime will be ensured
20. Establish the Incident Response System for Coordinated Response Actions
21. Capacity Development at the Community and Institutional level to enhance UFDM capabilities
22. Massive Public Awareness programmes covering Solid Waste Disposal, problems of Encroachments, relevance of Techno-legal Regime besides all other important aspects
23. Involve elected Public Representatives in Awareness Generation

1 Introduction

1.1 Overview

1.1.1 As a part of its mandate, the National Disaster Management Authority (NDMA) has been making efforts to prepare Guidelines for the management of different disasters and some cross-cutting themes. Even though urban flooding has been experienced over decades in India but sufficient attention was not given to plan specific efforts to deal with it. In the past, any strategy on flood disaster management largely focused on riverine floods affecting large extents of rural areas.

1.1.2 Mumbai floods of July 2005 turned out to be an eye-opener. Realizing that the causes of urban flooding are different and so also are the strategies to deal with them, NDMA has for the first time decided to address urban flooding as a separate disaster delinking it from floods. NDMA commenced its efforts to formulate the Flood Guidelines in 2006 and released them in 2008. Even while the Flood Guidelines were under preparation, efforts commenced to formulate these Urban Flood Guidelines in August 2007.

1.2 Urban Flooding is Different

1.2.1 Urban flooding is significantly different from rural flooding as urbanisation leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, flooding occurs very quickly due to faster flow times (in a matter of minutes).

1.2.2 Urban areas are densely populated and people living in vulnerable areas suffer due to flooding, sometimes resulting in loss of life. It is not only the event of flooding but the secondary effect of exposure to infection also has its toll in terms of human suffering, loss of livelihood and, in extreme cases, loss of life.

1.2.3 Urban areas are also centres of economic activities with vital infrastructure which needs to be protected 24x7. In most of the cities, damage to vital infrastructure has a bearing not only for the state and the country but it could even have global implications. Major cities in India have witnessed loss of life and property, disruption in transport and power and incidence of epidemics. Therefore, management of urban flooding has to be accorded top priority.

1.2.4 Increasing trend of urban flooding is a universal phenomenon and poses a great challenge to urban planners the world over. Problems associated with urban floods range from relatively localised incidents to major incidents, resulting in cities being inundated from hours to several days. Therefore, the impact can also be widespread, including temporary relocation of people, damage to civic amenities, deterioration of water quality and risk of epidemics.

1.3 Contributory Factors

Floods in urban areas can be attributed to one or a combination of different factors listed in Table 1.1.

Table 1.1: Factors Contributing to Urban Flooding

Meteorological Factors	Hydrological Factors	Human Factors
• Rainfall • Cyclonic storms • Small-scale storms • Temperature • Snowfall and snowmelt	• Soil moisture level • Groundwater level prior to storm • Natural surface infiltration rate • Presence of impervious cover • Channel cross-sectional shape and roughness • Presence or absence of over bank flow, channel network • Synchronization of run-offs from various parts of watershed • High tide impeding drainage	• Land use changes (e.g. surface sealing due to urbanization, deforestation) increase runoff and sedimentation • Occupation of the flood plain and thereby obstructing flows • Inefficiency or non-maintenance of infrastructure • Too efficient drainage of upstream areas increases flood peaks • Climate change effects, magnitude and frequency of precipitation and floods • Urban micro-climate may enforce precipitation events • Sudden release of water from dams located upstream of cities/towns * • Failure to release water from dams resulting in backwater effect * • Indiscriminate disposal of solid waste *

Source: Adapted from *Urban Food Risk Management: A Tool for Integrated Flood Management, AFPM document, GWP and WMO, 2008*

* Three more human factors are added in the Indian Context.

1.4 Trend of Urbanization in India

1.4.1 In 2001, there were about 286 million people residing in urban areas in the country accounting for about 27.8 % of the total population. Urban population is projected to be around 433 million by 2021. There is a marked impact of globalisation on urban growth, which is increasingly concentrated in and around urban areas, large and small. The trend of urbanisation in India is shown in Table 1.2.

Table 1.2: Trend of Urbanization in India

Sl. No.	Details	Year			
		1951	1991	2001	2021 (Estimated)
1.	No. of Urban Agglomerations, Cities & Towns	2765	3768	5161	----------
2.	Urban Population (in million)	62.44	216.61	285.35	433.00
3.	Percentage of total population	17.3	25.71	27.8	32.3

Source: Office of the Registrar General India, 2001 (Population totals for India and States for the Census of India – 2001)

1.5 Census Towns

1.5.1 As per the 2001 Census, there are 5161 census towns. The towns include statutory towns (as notified by government) and census towns as identified by the census on the basis of well-defined criteria. In India, a census town is one which has a minimum population of 5,000, at least 75 per cent of whose male working population is engaged in non-agricultural pursuits and density of whose population is more than 400 per sq km. When towns grow in area and population, the areas adjoining the notified core town(s) also may acquire urban characteristics. Therefore, for proper representation, the Census also provides data on the Urban Agglomerations (UAs), which comprise core town(s) and its outgrowths meeting the urban characteristics. Delhi, Kolkata, Chennai and Mumbai are examples of such Urban Agglomerations. There are 4378 Urban Agglomerations in the country.

1.5.2 The size of urban population is categorized by the class of towns/ urban agglomerations. The census towns are divided into six classes on the basis of population. Distribution of urban population in India by class and towns along with area covered is shown in Table 1.3.

Table 1.3: Distribution of Urban Population by Class of Towns, India - 2001 Census

Size Class	No. of Towns	Total Population	Per cent	Total Area in sq km	Per cent	Density
All Classes	5161	286119689*	100	77370.50	100	3675
Class I	441	178224290	62.3	24717.34	31.95	7157
Class II	496	34451500	12	10145.08	13.11	3371
Class III	1388	42119280	14.7	19412.17	25.09	2161
Class IV	1561	22593015	7.9	15406.14	19.91	1466
Class V	1041	7889668	2.8	6742.61	8.71	1169
Class VI	234	841936	0.3	947.17	1.22	848

Source: Office of the Registrar General India (2001)
* Information from 27 cities and towns under all classes is not available

1.5.3 While the total area covered by 5161 cities/towns belonging to all classes cover 77370.50 sq km, 2325 cities and towns of class I, II and III is about 54274.59 sq km.

1.6 Urbanisation and Pressure on Land

1.6.1 Urban areas are normally centres of commercial activity and continue to attract migrants in large numbers in search of employment from different areas. Rapid urbanization puts a lot of pressure on land and as a result, habitations keep coming up in the natural areas/flood plains. This is happening universally including in U.K. According to the Pitt's Report (2008), most of the houses affected by the floods in UK in 2007 were constructed during the last 25 years.

1.6.2 In Indian cities and towns, large habitations are coming up in low-lying areas, often encroaching over drainage channels. In some cases, houses are constructed even on top of nallahs and drains. Encroachment in the immediate upper catchments of hilly urban area has also caused serious flooding in the flood plains of cities surrounded by hills.

1.6.3 In the absence of a proper sewerage system, most of the habitations discharge their sewage into the existing stormwater channels. The net result has been that the width of the natural drainage channels has become inadequate and the capacity for draining the rainwater has been greatly reduced.

1.6.4 Moreover, urbanisation leads to increase in impervious areas which, in turn, significantly increases the rate of runoff, resulting in overwhelming of designed capacity of the stormwater drainage system. As a result of all these happenings, even small amounts of rainfall can cause urban flooding.

1.7 Weather Systems causing Rainfall

Major weather systems causing rainfall in different seasons in India are briefly discussed below.

1.7.1 Southwest Monsoon

1.7.1.1 Southwest monsoon (also known as Summer Monsoon) season (June-September) is the main rainy season in India during which the country receives over 70 to 75 per cent of its annual rainfall. The regions which receive the largest rainfall are along the west coast of India, north-eastern states, West Bengal and coastal Orissa. Heavy rainfall is a day-to-day occurrence during this season in some part or the other. In India, urban flooding is mostly due to heavy rainfall during this season.

1.7.1.2 Embedded in monsoon system, there are other synoptic systems such as vortices (lower/mid-tropospheric cyclonic circulation, off-shore vortices along the west coast, low pressure areas, depressions and cyclones), troughs (monsoon trough, off-shore trough along the west coast, north-south troughs over peninsular India during break monsoon conditions) and east-west wind shear zone in the lower troposphere that largely enhance the monsoon rainfall activity. Besides monsoon systems, orography plays a very crucial role in enhancing rainfall distribution. Heavy rainfall associated with each of these individual systems, by and large, follows a set pattern.

1.7.2 Northeast Monsoon

1.7.2.1 After the retreat of southwest monsoon, northeast monsoon (also known as Winter Monsoon) starts around the middle of October, causing significant amount of rainfall over

southern parts of peninsular India covering South Andhra Pradesh, Tamil Nadu, Puducherry, Kerala, South Karnataka, Andaman & Nicobar Islands and Lakshadweep. Heavy rainfall is a common occurrence over these areas during this period of northeast monsoon covering middle of October to end of December.

1.7.3 Depressions and Cyclones

1.7.3.1 Depressions are low pressure systems around which wind blows in an anti-clockwise manner in the Northern Hemisphere and where wind speed is between 31 km/h and 49 km/h over the sea. In India, a depression may originate over the sea or land and may cause copious rainfall along its path. Some depressions originating over the ocean may develop into tropical cyclones where wind speed in the circulation is 62 km/h or more. The tropical cyclone can intensify and move towards land. These are associated with hazards like very strong winds, very heavy rainfall and storm surges. After crossing the coast, they weaken into depressions and move across the land providing heavy to very heavy rainfall along its path over much of the land it covers. Rainfall associated with cyclone is dependent on the size, forward speed, direction of movement, duration and intensity of the system. Total rainfall at a place is more for a slow-moving cyclone as compared to a fast moving one. Also, for large cyclones, the rainfall is greater when compared with relatively small-sized cyclones.

1.7.4 Western Disturbances

1.7.4.1 Western disturbances are extra-tropical weather systems (low pressure areas) which move from west to east, regularly, causing widespread rainfall over the extra-tropical areas (covering the states of Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Delhi, Rajasthan and Uttarakhand) round the year. Their frequency and intensity varies from season to season. These are more frequent and more intense between November and March.

1.7.5 Thunderstorms

1.7.5.1 Thunderstorms are very common tropical weather phenomena observed in India round the year in some part or the other. Individually, these are localized short duration transient weather phenomena. These weather systems can also cause localized heavy to very heavy rainfall sometimes leading to local flooding. Thunderstorms are very frequent and sometimes very severe in summer, especially over north-east India causing heavy rainfall and floods. Thunderstorms during the monsoon season, though less frequent, greatly enhance the quantity of rainfall locally and are the major source of short duration heavy rainfall leading to flash floods/ flooding.

1.7.6 Cloudburst

1.7.6.1 Cloudburst is a disastrous weather event in which, heavy rainfall occurs over a localized area at a very fast rate. The rate of rainfall may be of the order of 100 mm/hr. Cloudburst in India occurs during the monsoon season over the orographically dominant regions like Himalayan region, north-eastern states and Western Ghats and in other areas as well. Associated convective clouds can extend upto a height of 15 km.

1.7.7 Interaction of Trough in the Westerlies and Monsoon Systems

1.7.7.1 Interaction of extra-tropical trough in the westerlies and monsoon systems, at times, causes extensive rainfall in its forward sector,

with widespread heavy-to-very heavy rainfall in north India causing floods.

1.8 Rainfall Description Terms

1.8.1 In India, rainfall is measured at 0830 IST everyday for the past 24 hours. Description terms for the spatial distribution and intensity of rainfall are shown in Table 1.4.

1.9 Monthly Variability of Rainfall

1.9.1 The monsoons make a major contribution to rainfall in India. The south-west monsoon contributes over 70 to 75 per cent of the annual rainfall, followed by the north-east monsoon.

1.9.2 Fig. 1.1 shows the monthly rainfall in some of the major cities of India. It can be seen that the average annual rainfall varies from 2932 mm in Goa and 2401 mm in Mumbai on the higher side to 669 mm in Jaipur on the lower side. Looking at the rainfall in Mumbai, it can be seen that the rainfall pattern and temporal duration is similar to all other cities which receive maximum rainfall from the south-west monsoon. While Mumbai receives a maximum of 2401 mm of rainfall during the monsoon, in the month of July alone it receives 868 mm.

Table 1.4: Description Terms for the Spatial Distribution and Intensity of Rainfall

I. Spatial Distribution of Rainfall		
Distribution	**No. of Places**	**Description**
Isolated	One or two places	<25% of stations gets rainfall
Scattered	At a few places	(26–50)% of stations gets rainfall
Fairly Widespread	At many places	(51–75)% of stations gets rainfall
Widespread	At most places	(76–100)% of stations gets rainfall
Dry	-	No station reported rainfall
II. Intensity of Rainfall		
Descriptive Term used	**Rainfall amount in mm (24 hours)**	
No Rain	0.0	
Very Light Rain	0.1- 2.4	
Light Rain	2.5 – 7.5	
Moderate Rain	7.6 – 35.5	
Rather Heavy	35.6 – 64.4	
Heavy Rain	64.5 – 124.4	
Very Heavy Rain	124.5 – 244.4	
Extremely Heavy Rain	>244.5	
Exceptionally Heavy Rain	When the amount is a value near about the highest recorded rainfall at or near the station for the month or season. However, this term will be used only when the actual rainfall amount exceeds 120 mm.	

Source: *India Meteorological Department*

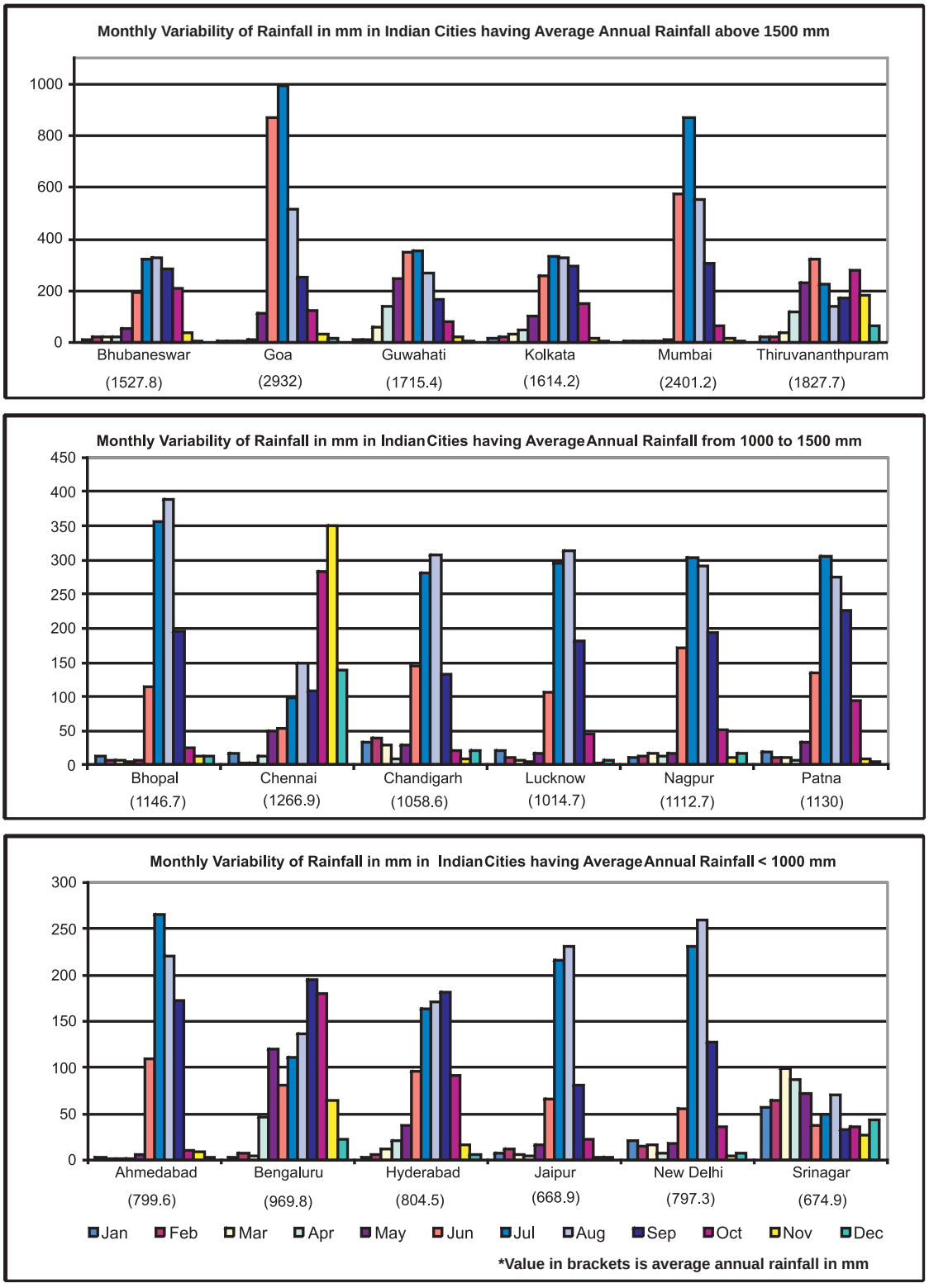

Fig. 1.1 Monthly Variability of Rainfall in some important Indian Cities (Compiled on the basis of IMD Data)

Note: Different scales are used for rainfall for different categories of cities

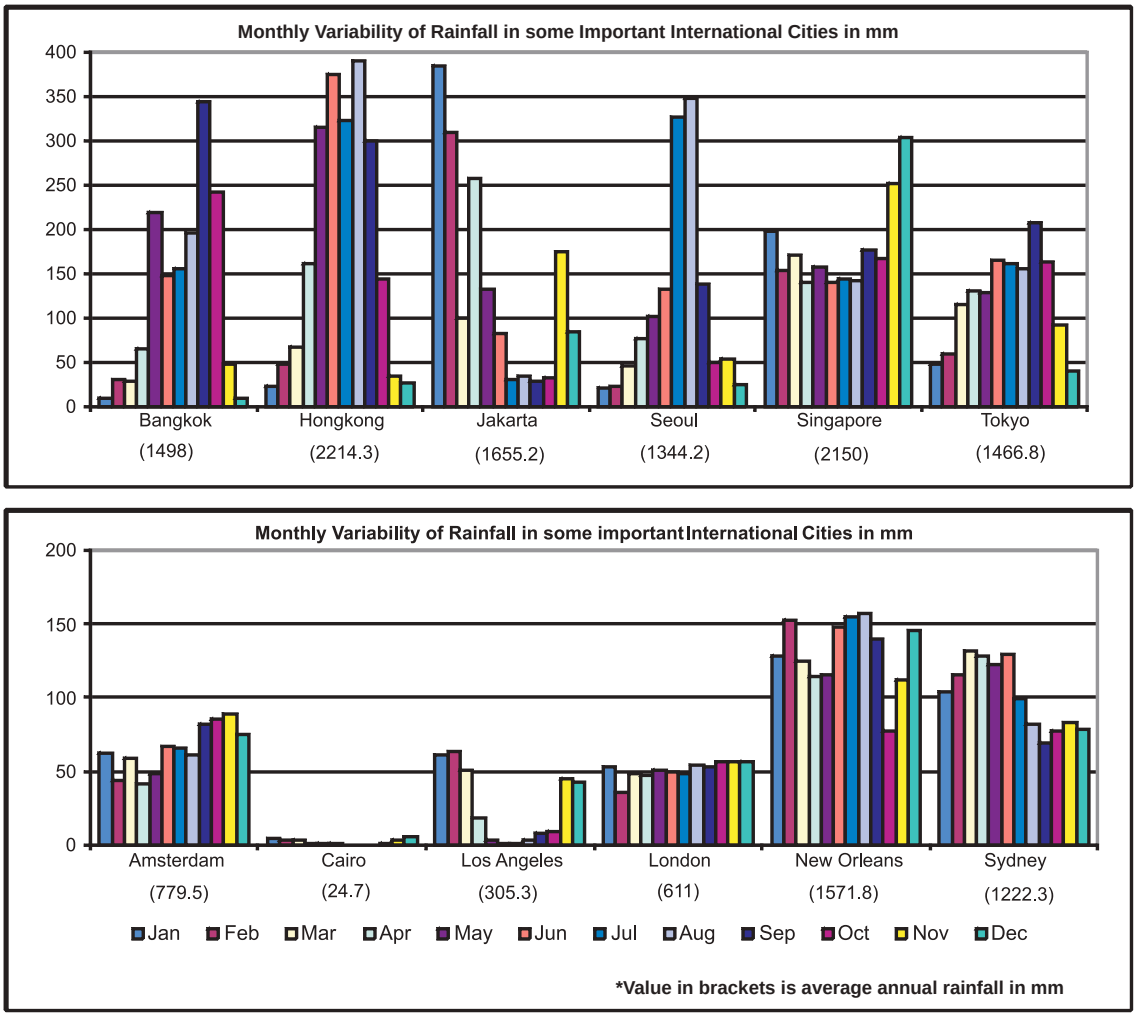

Fig. 1.2 Monthly variability of Rainfall in some important World Cities (Compiled on the basis of WMO data)
Note: Different scales are used for rainfall for different categories of cities

1.9.3 Fig. 1.2 shows the rainfall in major cities of the world including Mumbai. It can be seen that the average monthly rainfall of 868 mm in July in Mumbai far exceeds the average annual rainfall of 611 mm of London. It is also interesting to note that while Singapore receives the annual rainfall of the order of 2150 mm, this is spread more or less uniformly throughout the year, as in the case of London.

1.9.4 In view of high intensity monsoon rainfall in India, different strategies are required to deal with urban flooding.

1.10 Micro-Climate and Urban Heat Island Effect

While general weather systems cover extensive areas, micro-climate in urban areas has great relevance for urban flood DM. It has been observed that there is a significantly higher rainfall recorded over many urban areas over the years. Apparently, the urban heat island effect is responsible for this. It has been observed that the temperature over urban areas is higher than the surrounding areas.

Whenever the rain bearing clouds pass over these areas, the hot air pushes the clouds up, resulting in highly localized rainfall which may sometimes be of high intensity.

1.10.1 Urban Heat Island Effect and Increasing Rainfall

It is now well-documented that urbanization leads to an increase in rainfall. As early as 1921, scientists noted thunderstorm formation over large cities while there were none over rural areas. Recent studies such as the Metropolitan Meteorological Experiment (METROMEX) conducted in St. Louis, USA, found that urbanisation led to a 5-25 per cent increase in summer precipitation within and 50-75 km downwind of the city. This can be very well explained by the Urban Heat Island Effect – the rising heat induces cloud formation while the winds interact with urban induced convection to produce downwind rainfall. National Aeronautics and Space Administration (NASA) has indicated increased rainfall intensities over urban areas due to the Urban Heat Island Effect.

Fig. 1.3 Rising Heat and Cloud Formation as a Result of the Urban Heat Island Effect
Source: *National Aeronautics and Space Administration, USA*

1.10.2 Moreover, in a study of urbanization effect on convective precipitation in Mexico, analysis of historical records of hourly

Fig. 1.4 Winds Interact with Urban-induced Convection to Produce Downwind Rainfall
Source: *National Aeronautics and Space Administration, USA*

precipitation for an urban station showed an increase in the frequency of intense (>20 mm/h) rain showers and that the day time Heat Island Effect was associated with the intensification of rain showers. In India, urban heat islands over Pune and Chennai have been reported. There has been an increase in the average annual rainfall of Hyderabad from 806 mm in 1988 to 840 mm in 2002.

1.11 Climate Change

1.11.1 Climate Change and Sea-level Rise

1.11.1.1 Global warming is the increase in the average temperature of Earth's near-surface air and oceans. According to the 2007 Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), global surface temperature that increased 0.74 ± 0.18^0 C (1.33 ± 0.32^0 F) during the 20th century, was caused by increasing concentrations of greenhouse gases as a result of burning of fossil fuel and deforestation.

1.11.1.2 Climate model projections summarized in the IPCC report indicate that the global

surface temperature is likely to rise a further 1.1 to 6.4^0 C (2.0 to 11.5^0 F) during the 21st century. An increase in global temperature will cause sea levels to rise and will change the amount and pattern of precipitation. Other likely effects include changes in the frequency and intensity of extreme weather events.

1.11.1.3 The temperature increase is widespread over the globe and is greater at higher northern latitudes. Average Arctic temperatures have increased at almost twice the global average rate, in the past 100 years. Land regions have warmed faster than the oceans. Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m and that the ocean has been taking up over 80% of the heat being added to the climate system.

1.11.1.4 Increases in sea-level are consistent with warming. Global average sea-level rose at an average rate of 1.8 [1.3 to 2.3] mm per year, over 1961 to 2003, and at an average rate of about 3.1 [2.4 to 3.8] mm per year, from 1993 to 2003.

1.11.1.5 As a result of sea-level rise, there will be increasing submergence of coastal cities, resulting in damage to property and loss of economic activity. Future strategies should recognize that sea-level rises worldwide cannot be reversed. The only alternative is to have increased investment in flood defences. For example, the Municipal Corporation of Greater Mumbai (MCGM) is now in the process of installing floodgates in combination with high-discharge pumps at eight of the hitherto ungated sea outlets.

1.11.2 Climate Change and Increasing Rainfall

1.11.2.1 The IPCC has observed that "the marked increase in atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) since 1750 is the result of human activities" and that "the implications of global warming over the coming decades for our industrial economy, water supplies, agriculture, biological diversity and even geopolitics are massive". If carbon emissions continue unabated, these are likely to result in an increase in the total precipitation (and hence run-off) and increased storm intensities.

i) Precipitation is projected to be concentrated into more intense events with longer periods of little precipitation,

ii) Wet extremes becoming more severe in many areas where the mean precipitation increases,

iii) Precipitation intensity (e.g., proportionately more precipitation per precipitation event) is projected to increase over most regions,

iv) Increase in precipitation extremes is greater than changes in the mean precipitation,

v) The increase in mean and extreme precipitation in various regions has been attributed to contributions from both dynamic and thermodynamic processes associated with global warming,

vi) The greater increase in extreme precipitation compared to the mean is attributed to the greater thermodynamic effect on the extremes due to increases in water vapour, mainly over subtropical areas. Changes in circulation also

contribute to the pattern of precipitation intensity changes at middle and high latitudes,

vii) Increased rainfall intensity and an implied increase in flooding shows a projected increase in extreme rainfall intensity with the extra-tropical surface lows, particularly over Northern Hemisphere (NH) land, with an implied increase in flooding,

viii) Similar results for summer precipitation with implications for greater flooding in the Asian monsoon region in a future warmer climate, and

ix) Globally averaged time series in the multi-model analysis shows simulated increases in precipitation intensity during the 20th century continuing through the 21st century along with a somewhat weaker and less consistent trend of increasing dry periods between rainfall events for all scenarios.

Irish Academy of Engineering in a landmark report on Ireland At Risk – Critical Infrastructure and Climate Change warned that storm surges combined with a sea-level rise of 50 cm would mean that a one-in-100-year flood could happen as often as every five years.

Source: *Report published by Irish Academy of Engineering, November 2009*

A study of 165 stations across the Indian region with a long data series, shows that majority of them have reported their highest 24-hour rainfall during 1961-1980 with an alarming rise in their intensity thereafter. Record rainfall events on different time scales (hourly to annual) have also taken place in the recent decades. These events may be associated with the global and regional warming signalling the effect of the climate change over the region. Therefore, if the trend of the global warming continues, the extreme point rainfall events also may continue to occur in the future. They would pose serious problems in some parts due to their adverse impact on the socio-economic issues like the damage to life and the property. Such spells, especially at the hill stations would result in the environmental degradation due to soil erosion, river silting, landslides, etc. In view of these points, it is imperative that proper care need be exercised in near future for the work of town planning, DM and the environmental protection for the sustainable development of the human beings over the Indian region.

(Excerpts from Indian Institute of Tropical Meteorology, Research Report No. R.R. 123, August 2009)

1.12 City Scenarios

1.12.1 Cities may be situated on the coasts, river banks, near downstream/ upstream of dams, inland or in hilly areas. There are several cities which may fall under more than one of these categories.

Rainfall occurs in different seasons on differently located cities in India. Local rainfall finds its way into streams/ nallahs and finally joins a river or the sea through local drains in coastal areas. Geographically, the cities/ towns may be categorized as per the following scenarios:

1.12.2 Coastal Cities

Coastal cities/towns, which are located on the coastline, experience flooding due to localized rainfall, storm surges caused by cyclones. They also get affected by high tides, coinciding with localized rains.

1.12.3 Cities on Major Rivers

Many cities/towns are located on the banks of small and big rivers. Floods in those rivers cause inundation of the flood plains as very often urban growth has indiscriminately spread into flood plains, reducing the area into which floods can naturally overflow.

1.12.4 Cities near Dams/Reservoirs

There are cities/towns which are located along a river, either downstream or upstream of dams/ reservoirs. Those located downstream of reservoirs can get flooded by release of water in excess quantities. Sometimes cities/towns located upstream of a dam/reservoir also get affected by rising level of backwaters when release of water is sometimes withheld during the flood season. There have been instances when water was released suddenly without appropriate notice, causing severe loss of life and property.

1.12.5 Inland Cities

Cities/towns located inland can experience floods largely because of localized heavy rainfall within the watershed due to overwhelming of the stormwater drainage system capacity.

1.12.6 Cities in Hilly Areas

Cities/towns located in the hilly areas experience flash floods due to localized heavy rainfall which can also result in landslides. Sometimes, habitations in hilly areas comprising a part of large cities/towns, also get affected in a similar manner.

1.13 Genesis of National Guidelines

1.13.1 NDMA took a path-breaking decision to deal with urban flooding as a separate disaster, delinking it from riverine floods. The first initiative was taken by organizing a Brain-storming Session in August 2007, followed by a National Workshop on October 11 and 12, 2007 at Pune. It was attended by representatives from Central, State Governments and Urban Local Bodies (ULBs) from different parts of the country, experts from academic and scientific communities. Different committees were constituted and, subsequently, Regional Workshops, State level Workshops, Core Group Meetings, Review Meetings and an Indo-US Workshop were held during 2007-2009.

1.13.2 A nine-step process has been followed that includes review of the present status and assessment of critical gaps. This has been done by taking on board the nodal agencies, ministries/ departments of GoI and State governments/UTs, academic, scientific and technical institutions and NGOs, and obtaining exhaustive feedback from city/town level through interaction with Members of Parliament (MPs), Members of Legislative Assemblies (MLAs) and elected representatives from ULBs.

International Indo-US Workshop on "Urban Flood Disaster Management: Administrative, Technical and Scientific Issues" by NDMA and USAID

An International Indo-US Workshop with the theme "Urban Flood Disaster Management: Administrative, Technical and Scientific Issues" was organized in Hyderabad, from 7 to 9 January 2008, jointly by NDMA and USAID, to get an overview of the American practices for managing urban flooding and to incorporate the feasible measures in the NDMA Guidelines.

The Workshop was attended by the Asst. Secretary of the Army (Civil Works) of the US Government, officers of the US Army Corps of Engineers and US Association of State Floodplain Managers, from the US side. From the Indian side, it was attended by representatives of the Government of India, state governments, academic and scientific institutions and other stakeholders.

There was extensive coverage of key issues from both sides, related to urban flood disaster management (UFDM), such as flood risk management state and local roles, urban regulation issues, challenges in UFDM, role of science and technology in flood disaster management, flood-risk communication and perception, development of flood warning and response systems, emergency management technologies for monitoring and mitigation of flooding events, New York City Hurricane preparedness plan, impact of global climate change on planning for flood management and future research and development priorities.

The Workshop provided valuable inputs to the Guidelines on these issues.

2 Institutional Framework and Arrangements

2.1 Institutional Framework

2.1.1 National Disaster Management Authority

2.1.1.1 The NDMA, as the apex body in the GoI, has the responsibility of laying down policies, plans and guidelines for DM and coordinating their enforcement and implementation for ensuring timely and effective response to disasters. The Guidelines will assist the central ministries, departments and states to formulate their respective plans. It will approve the national DM plan, prepared by the National Executive Committee (NEC) and plans of the central ministries and departments. It will take such other measures as it may consider necessary, for the prevention of disasters, or mitigation, or preparedness and capacity building, for dealing with a threatening disaster situation. To this end, it will be the responsibility of every central ministry or department to provide assistance to NDMA, and the state governments will also extend necessary cooperation and assistance. It will oversee the provision and application of funds for mitigation and preparedness measures. It has the power to authorise the departments or authorities concerned, to make emergency procurement of provisions or materials for rescue and relief in a threatening disaster situation or disaster. It will also provide such support to other countries in times of disasters as may be determined by the central government. The general superintendence, direction and control of the National Disaster Response Force (NDRF) are vested in and will be exercised by the Authority. The National Institute of Disaster Management (NIDM) will work within the framework of the broad policies and guidelines of NDMA.

In essence, NDMA will concentrate on prevention, preparedness, mitigation, rehabilitation, reconstruction and recovery and also formulate appropriate policies and guidelines for effective and synergised national disaster response and relief. It will also coordinate the enforcement and implementation of policies and plans.

2.1.2 National Executive Committee

2.1.2.1 NEC comprises the Secretary to the GoI in the Ministry/Department having administrative control of the subject of DM, as the chairperson, and the secretaries to the GoI in the ministries/departments of Agriculture, Atomic Energy, Defence, Drinking Water Supply, Environment and Forests, Finance (Expenditure), Health, Power, Rural Development, Science and Technology, Space, Telecommunications, Urban Development, Water Resources and the Chief of the Integrated Defence Staff of the Chiefs of Staff Committee as members. Secretary,

NDMA, will be a special invitee to the meetings of NEC.

2.1.2.2 NEC is the executive committee of NDMA, and it is mandated to assist NDMA in the discharge of its functions and also ensure compliance of the directions issued by the central government for the purposes of DM. One of the important functions assigned to NEC is to coordinate the immediate response in the event of any threatening disaster situation or disaster on behalf of NDMA. Based on the policy and guidelines, NEC will be responsible for preparing the national plan, getting it approved by NDMA and then operationalising it. NEC will also require any department or agency of the government to make available to NDMA or state authorities, such men or material resources as are available with it, for the purposes of handling threatening disasters, emergency response, rescue and relief. It will also perform such other functions as NDMA may require it to perform.

2.1.2.3 The functions presently being discharged by the Inter-Ministerial Group (IMG) in appraising the assessments made by the Inter-Ministerial Central Teams of the damage, the requirement of funds from the National Calamity Contingency Fund (NCCF) and recommending the quantum of assistance to be provided to the states will now be discharged by NEC.

2.1.3 National Disaster Response Force

2.1.3.1 The DM Act 2005 has mandated the constitution of the NDRF for the purpose of specialised response to a threatening disaster situation or disaster. The general superintendence, direction and control of the force is vested in, and exercised by, NDMA and the command and supervision of this force is vested in the Director General of NDRF.

2.1.3.2 Presently, NDRF comprises eight battalions with further expansion of two additional battalions that have been sanctioned by the Government and are in the process of being formed. These battalions are located at strategic locations and will be deployed proactively as required. This force is being trained and equipped as a multi-disciplinary, multi-skilled, high-tech force with state-of-the-art equipment. To ensure prompt response during any disaster, each of the NDRF battalions will have three to four states/ UTs as their areas of responsibility. Further, a National Academy will be set up to provide training for trainers in DM and to meet the related national and international commitments.

2.1.3.3 Each battalion will have three to four Regional Response Centres (RRCs) at high vulnerability locations where trained personnel with equipment will be pre-positioned. NDRF units will maintain close liaison with the state administration and be available to them pro-actively, thus avoiding long procedural delays in deployment in the event of any serious threatening disaster situation. Besides, NDRF will also have a pivotal role in Community Capacity Building and Public Awareness. NDRF is also enjoined with the responsibility of basic training of personnel of the State Disaster Response Force (SDRF), Police, Civil Defence, Home Guards and other stakeholders in disaster response.

2.1.4 State Disaster Response Force

2.1.4.1 All States and UTs will be required to train some personnel of their existing armed police battalions in DM, as they are critical first responders. States will ultimately aim at equipping and training, one battalion equivalent force, progressively to generate

specialist response from within their existing resources. These forces will also train some female personnel for looking after the needs of the women. NDRF Battalions and their Training Institutions will assist the states/ UTs in this effort. The states/ UTs will also be encouraged to set up DM training facilities in their respective Police Training Colleges and include this subject in their basic and in-service courses, for the non-gazetted and gazetted officers in those Colleges.

2.1.5 National Reserves

2.1.5.1 The experience of major disasters in the last decade has clearly established the need for a national initiative for pre-positioning of some essential reserves at crucial locations, including some for high altitude areas. Those reserves are intended to augment the resources of the states. They will be co-located with NDRF battalions at nine different locations in the country and released to the states on the recommendation of the NDMA.

2.1.6 National Institute of Disaster Management

2.1.6.1 NIDM has institutional capacity development as one of its major responsibilities, along with training, documentation of research, networking and development of a national level information base. NIDM will function closely within the broad policies and guidelines laid down by NDMA and assist in developing training modules, impart training to trainers and DM officials and strengthening of Administrative Training Institutes (ATIs) in the state. It will also be responsible for synthesising research activities. NIDM will be geared towards emerging as a 'Centre of Excellence' at the national and international levels.

2.1.7 State Disaster Management Authority

2.1.7.1 At the state level, the State Disaster Management Authority (SDMA) headed by the Chief Minister, will lay down policies and plans for DM in the state. It will, *inter alia,* approve the state plan in accordance with the guidelines laid down by NDMA, coordinate the implementation of the state plan, recommend provision of funds for mitigation and preparedness measures and review the developmental plans of the different departments of the state to ensure integration of prevention, preparedness and mitigation measures.

2.1.7.2 The state government will constitute a State Executive Committee (SEC) to assist the SDMA in the performance of its functions. The SEC will be headed by the Chief Secretary to the state government and coordinate and monitor the implementation of the national policy, the national plan and the state plan. It will also provide information to NDMA relating to different aspects of DM.

2.1.8 District Disaster Management Authority

2.1.8.1 At the cutting edge level, the District Disaster Management Authority (DDMA), headed by the District Magistrate, with the elected representative of the local authority as the co-chairperson, will act as the planning, coordinating and implementing body for DM and take all necessary measures for the purposes of DM in the district, in accordance with the guidelines laid down by NDMA and SDMA. It will, *inter alia,* prepare the district DM plan including the response plan for the district, coordinate and monitor the implementation of the national and state policies, the national, state

and district plans and ensure that the guidelines for prevention, mitigation, preparedness and response measures, laid down by NDMA and SDMAs, are followed by all departments of the government at the district level and the local authorities in the district.

2.1.9 Civil Defence

2.1.9.1 In any disaster, it is the community that is always the first responder. Outside help comes in only later. Training the community and making such response organised, is therefore of utmost importance.

2.1.9.2 The mandate of the civil defence has already been redefined to assign them an effective role in the field of DM. They will be deployed for strengthening the community preparedness and public awareness. A culture of voluntary reporting to duty stations in the event of any disaster will be encouraged. A proper civil defence set up in every District will be a boon for disaster response as the neighbourhood community is always the first responder in any disaster. The proposal to make civil defence District centric and be involved in disaster response has already been approved by the GoI. Its phase-wise implementation has also begun. State governments will ensure their operationalisation in their respective districts.

2.1.9.3 Integration of the Capacity Development into DM can work as a great catalyst for organising community capacity building. Civil defence has been authorised in 225 designated towns in the country out of which 121 have already been activated where volunteers have been recruited and trained. There is a plan to revamp civil defence, extending its coverage to all the districts in the country and assigning it an important role in DM framework. According to the proposal for revamping, the primary role of civil defence will be community capacity building and creating public awareness in pre-disaster phase. The proposal envisages converting the town specific set-up of civil defence to a district specific set-up. It is proposed to have 18 persons employed, on full time basis, in each district-specific set-up, out of which eight will be the trainers and their duty will be to train volunteers. Till the revamping is finalised, states should start using the existing set up for training more and more volunteers and spreading awareness on the different aspects of DM. The state governments will also activate the remaining non-activated towns in a phased manner. The state governments/SDMAs and DDMAs will coordinate the human resources of the civil defence set up as well as those of other agencies for performing/ responding to various disaster-related activities.

2.1.9.4 In the meanwhile, the Civil Defence set-up already existing in the country will be immediately utilised to train the community for disaster response in the concerned districts of the already activated towns. The DG, Civil Defence, in their respective states will work out training modules for DM covering awareness generation, first aid and rescue drills. NIDM will prepare a comprehensive training module simultaneously and circulate it, which will be incorporated in the already ongoing training.

2.1.10 The Cabinet Committee on Management of Natural Calamities and the Cabinet Committee on Security.

2.1.10.1 Cabinet Committee on Management of Natural Calamities (CCMNC) has been constituted to oversee all aspects relating to the management of natural calamities, including assessment of the situation and identification

of measures and programmes considered necessary to reduce its impact, monitor and suggest long-term measures for the prevention of such calamities formulate and recommend programmes for public awareness for building up society's resilience to them. In specific cases, Cabinet Committee on Security (CCS) will also be kept informed of the manner in which these disasters are being managed. NDMA's linkages with these committees will be institutionalised.

2.1.11 National Crisis Management Committee

2.1.11.1 The National Crisis Management Committee (NCMC), comprising high-level officials of the GoI, headed by the Cabinet Secretary, will also deal with specified major crises. It will be supported by the Crisis Management Groups (CMG) of the central nodal ministries. The Secretary, NDMA, will be a member of this Committee.

2.2 Role of Central Ministries and Departments

As DM is a multi-disciplinary process, many central ministries and departments will have a key role in assisting NDMA in the discharge of its functions. The nodal ministry and other ministries and departments of the GoI, i.e., the Ministries of Home Affairs, Agriculture, Civil Aviation, Environment and Forests, Health, Atomic Energy, Space, Science and Technology, Earth Sciences, Water Resources, Mines, Railway, Department of North Eastern Region, etc., will continue to address specific disasters as assigned to them. Further, Ministry of Home Affairs (MHA) will act as the administrative ministry on the subject of DM.

2.2.1 Ministry of Home Affairs

2.2.1.1 Ministry of Home Affairs (MHA) has been the nodal ministry for DM in India since 2002. It provides administrative support to NDMA. It is also the nodal administrative agency for NDMA. MHA initiated the enactment of DM Act 2005 and on the basis of this NDMA, SDMAs and DDMAs are constituted in the country.

2.2.1.2 MHA has taken initiatives for a number of programmes including GoI-UNDP Disaster Risk Management (DRM) Programme, Information and Communication Technology (ICT) for Disaster Reduction, Program for Enhancement of Emergency Response (PEER), National Programmes for Capacity Building of Architects in Earthquake Risk Management (NPCBAERM), Capacity Building of Engineers in Earthquake Risk Management (NPCBEERM), Model Amendment in Town and Country Planning Legislations, Regulation for Land Use Zoning and Building Byelaws for Structural Safety, Development of City Disaster Management Plans under the Urban Earthquake Vulnerability Reduction Project and Model techno-legal regime for multi-hazard risk management in the States.

2.2.2 Ministry of Urban Development

Ministry of Water Resources/Central Water Commission (MoWR/CWC) has been the nodal ministry/agency for dealing with Floods, focusing on riverine floods affecting large extents of rural areas. NDMA had taken a decision to address urban flooding as a separate disaster de-linking it from Floods for the first time in the country and evolved these guidelines. Taking into consideration the fact that stormwater drainage system, which is one of the important components

of UFDM is allotted to Ministry of Urban Development (MoUD) under the business rules, NDMA had proposed that MoUD should be designated as the nodal ministry for Urban Flooding. Consultations were held with MHA, MoWR/CWC, Ministry of Earth Science/ India Meteorological Department (MoES/IMD), Department of Space/ National Remote Sensing Centre (DoS/NRSC), Department of Science and Technology/ National Spatial Data Infrastructure (DST/NSDI) and SoI, MoES and MoUD and they concurred with the proposal.

MoUD will be at the centre stage of all action points recommended in these guidelines. Adequate capacities must be built in the ministry in order to carry out identified functions in a challenging manner.

MoUD has launched various programme including JNNURM, Urban Infrastructure Development Scheme for Small & Medium Towns (UIDSSMT) and North Eastern Region Urban Development Programme (NERUDP), which have a lot of relevance for management of urban flooding. The ministry is also putting in place the National Urban Information System (NUIS). They have also set up a Committee of Experts for preparation of a Stormwater Drainage Manual.

2.2.2.1 Jawaharlal Nehru National Urban Renewal Mission

JNNURM is a flagship programme of the Government of India, the biggest so far in the urban sector. The major component of JNNURM is infrastructure provisioning including storm-water management system and sewerage system and will be carried out by different cities. This reform linked programme aims to make cities self-sustaining, efficient and responsive. The total fund earmarked for the project is Rs. 50,000 crores. The duration of the Mission is seven years, beginning from the year 2005- 2006 and it covers 65 cities. The Mission, for planned urban perspective frameworks for a period of 20-25 years (with 5-yearly updates) indicating policies, programmes and strategies of meeting fund requirements, would be prepared by every identified city.

In order to access funds under JNNURM, each city has to prepare a City Development Plan (CDP), Detailed Project Reports (DPRs) for the projects being proposed, and sign a Memorandum of Agreement containing the timeline for reforms. Funds can be released to cities based on the progress made on implementing the reforms and on utilization of the funds released.

2.2.2.2 Urban Infrastructure Development Scheme for Small and Medium Towns

UIDSSMT aims at improvement in urban infrastructure in towns and cities in a planned manner. It has subsumed the existing schemes of Integrated Development of Small and Medium Towns (IDSMT) and Accelerated Urban Water Supply Programme (AUWSP). The scheme applies to all cities/towns as per 2001 census, excepting 65 JNNURM cities/towns.

The objectives of the scheme are to:

i) Improve infrastructural facilities and help create durable public assets and quality oriented services in cities & towns,

ii) Enhance public-private-partnership in infrastructural development, and

iii) promote planned integrated development of towns and cities.

The State Governments may prioritize towns and cities on the basis of their felt-need. While prioritizing towns, states would take into account existing infrastructure, population of Scheduled Castes/Scheduled Tribes/minorities and special problems like hilly terrain. The components for assistance under the Scheme include all urban infrastructure development projects including water supply and sewerage.

2.2.2.3 North-Eastern Region Urban Development Programme

North-Eastern Region Urban Development Programme (NERUD) is a programme run with assistance from Asian Development Bank (ADB) covering North Eastern States. The NERUD Programme is to be implemented by MoUD in the North-Eastern Region (NER) of India, covering Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. It is to enable these states to meet their development challenges in the urban sector with the assistance of ADB for infrastructure investment in priority urban services, viz. (i) Water Supply, (ii) Sewerage and Sanitation, and (iii) Solid Waste Management, Project Management and Capacity Development of the ULBs through institutional and financial reforms. In Phase – I capital cities of 5 north eastern states, viz. Agartala (Tripura), Aizawl (Mizoram), Gangtok (Sikkim), Kohima (Nagaland) and Shillong (Meghalaya) are covered and Phase – II will cover the state capitals of Arunachal Pradesh, Assam and Manipur. The total cost of Phase-I of NERUDP is estimated at $285.7 million (₹1371.4 crore @ $1 = ₹ 48).

2.2.2.4 National Urban Information System

NUIS scheme was launched for creating an urban information system to meet the special requirements of urban planning. 158 cities and towns from Class-I to Class-VI from each State and Union Territory are being covered in phases. Under this Scheme, both attribute and thematic spatial data at various levels are being generated for urban planning and decision support. Twelve thematic spatial data layers, viz. urban land use/cover, physiography (outside city area), geomorphology (outside city area), geological structure (outside city area), lithology (outside city area), drainage, soil cover, texture and depth (outside city area), surface water bodies, road, rail, canal and transportation routes are being covered in the database. The database creation uses modern data sets such as satellite images and aerial photographs to generate comprehensive spatial data in 3 scales i.e. 1:10,000 for Zonal Development Plan/ Master Plan/Development Plan, 1:2000 for detailed Development Plan and on 1:1000 for utility planning for sewerage and drainage. It is also envisaged to use ground profiling/ penetrating radar technology for utility mapping. Such spatial data will be integrated with the conventional data as well as demographic database. This database will have all details of infrastructure, population, utilities and also digital elevation, including administrative boundaries.

2.2.2.5 Manual on Municipal Solid Waste Management

A Committee of Experts constituted by the MoUD prepared a Manual on Municipal Solid Waste Management in the year 2000. Among other things, it has a relevant section on stormwater drainage.

2.2.2.6 Committee on Stormwater Manual

MoUD has constituted an Expert Committee for the preparation of an Urban

Stormwater Drainage Manual which will take into account current international practices, Indian rainfall pattern, the specific locations of the cities and future needs. It is for the first time that such an exercise is being carried out in the country.

2.2.3 Ministry of Environment & Forests

2.2.3.1 Ministry of Environment and Forests (MoEF) is the nodal agency in the administrative structure of the Central Government, for the planning, promotion, co-ordination and overseeing the implementation of environmental and forestry programmes.

2.2.3.2 Municipal Solid Waste (Management & Handling) Rules, 2000.

Besides the Water (Prevention and Control of Pollution) Act of 1974 and Air (Prevention and Control of Pollution) Act of 1981, the Environment (Protection) Act was enacted in 1986. It is an umbrella legislation empowering central government to take measures necessary to protect and improve the quality of the environment by setting standards for emissions and discharges; regulating the location of industries; management of hazardous wastes, and protection of public health and welfare. This has relevance in the context of urban flooding.

Under this Act, MoEF has issued the Municipal Solid Waste (Management & Handling) Rules, 2000. The Municipal Solid Waste (MSW) Rules provide a framework encompassing collection, transportation, treatment and disposal of municipal solid waste. As already pointed out, improper dumping of Municipal Solid Waste (MSW) into drains/ nallahs is a major factor contributing to urban flooding.

2.2.3.3 Environmental Impact Assessment

In India, Environmental Impact Assessment (EIA) was been formally introduced in 1994. It relied on the institutional framework that has a strong legislative, administrative and procedural set-up. Both central and state authorities together are sharing the responsibility of its development and management.

2.2.3.4 National Lake Conservation Plan

The National Lake Conservation Plan (NLCP) was approved as a 100% centrally funded scheme during the Ninth Plan. Due to shortage of resources at that time, conservation of only 3 small lakes viz. Ooty and Kodaikanal in Tamil Nadu and Powai in Mumbai were taken up at a cost of ₹ 14.9 crore. The scheme now provides assistance to States at 70:30 sharing basis and till date 28 projects have been approved for conservation of 42 lakes at an estimated cost of about ₹ 508 crore. Since lakes/ water bodies act as retention/ detention bodies, improvement/ augmentation of their holding capacity has a definite bearing on the management of urban flooding.

2.2.4 Ministry of Water Resources

2.2.4.1 The Central Water Commission (CWC) is an apex Organization for flood management schemes of India. One of the major provisions of CWC is planning, establishment, Operation and Maintenance (O&M) of hydrological observation stations and flood forecasting systems in the entire country. CWC has taken the initiative of modenisation programme by installing sensor-based equipment for data collection, satellite-based communication, automatic flood forecast formulation, using available computerised mathematical models and automatic transmission/ dissemination of

flood forecasts/ flood information through Very Small Aperture Terminal (VSAT) technology for expeditious data collection, transmission and dissemination. The installation of network density has been followed from IX Plan to XI Plan and under XI Plan it is proposed to have additional 222 new telemetry systems in the country.

2.2.5 Ministry of Earth Sciences

2.2.5.1 IMD under MoES is the custodian of rainfall data in India and the rainfall data is archived at National Data Centre (NDC) of India Meteorological Department at Pune.

The IMD is mandated as under:

i) To take meteorological observations and to provide current meteorological information and forecast for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, off-shore oil explorations, etc.,

ii) To warn against severe weather phenomena like tropical cyclones, norwesters, duststorms, heavy rains and snow, cold and heat waves, etc., which cause destruction of life and property,

iii) To provide meteorological statistics required for agriculture, water resource management, industries, oil exploration and other nation-building activities,

iv) To conduct and promote research in meteorology and allied disciplines, and

v) To detect and locate earthquakes and to evaluate seismicity in different parts of the country, for development projects.

IMD has taken the initiative of a modernisation plan in the Eleventh Five Year Plan. The details are discussed under Chapter 3.

2.2.5.2 Indian Institute of Tropical Meteorology (IITM) functions as a national centre for basic and applied research in monsoon meteorology. Its primary functions are to promote, guide and conduct research in the field of meteorology in all its aspects.

2.2.5.3 The national meteorological and hydrological services provide timely advice and early warnings on weather and climate conditions for prevention/mitigation, sustainable development and policy formulation. They contribute to the development and implementation of policy framework, relating to protection of life and property, increased awareness and preparedness, increased safety on land, at sea and in air enhance quality of life, sustainable economic growth, protection of environment, reliable and timely advice to policy makers and protection of natural ecosystem, including both fresh water and marine ecosystem.

2.2.6 Ministry of Defence

2.2.6.1 Armed forces, comprising of Army, Navy, Air Force besides Coast Guards have always played a pivotal role in DM, including rescue, evacuation, restoration of casualties, roads, dropping of relief supplies, etc. a very important role during disasters. The Armed Forces are quickest to reach the affected areas for delivering timely action. Restoration of communication by them is very often a major contribution. The Air Force assists in search and rescue, evacuation and airdropping of relief supplies. The Indian Navy and Coast Guard divers assist in rescue operations as well.

2.2.7 Ministry of Science & Technology

2.2.7.1 Survey of India (SoI) under the Ministry of Science & Technology has a major role in mapping of urban areas, which will be the basic requirement for urban planning and therefore very relevant to urban flooding.

2.2.8 Ministry of Space

2.2.8.1 NRSC under the Ministry of Space has an important role in preparing Airborne Laser Terrain Mapping (ALTM) data and National Database for Emergency Management (NDEM). Data provided by ALTM will be very useful for geospatial urban planning. NRSC has initiated the urban flooding programme under the Indian Space Research Organisation's (ISRO) Disaster Risk Management Programme.

2.3 The State Governments

2.3.1 At the local level the initiatives by state govt. departments like Municipal Administration and Urban Development (MA&UD), Public Works Department (PWD)/ Irrigation/ Roads and Buildings, Education, Health, State Pollution Control Board (SPCBs), State Remote Sensing Application Centres (SRSACs), etc. have a definite role in the context of management of urban flooding. However, at the cutting-edge level, it is the ULBs which are responsible for the management of urban flooding.

2.3.2 The department/section under the municipal local bodies dealing with Town and Country Planning, engineering, sanitation, besides water supply and sewerage, have a definite role in UFDM.

2.4 Urban Local Bodies

2.4.1 An important initiative of the Government of India was to strengthen municipal governance with the enactment of the Constitution (74th Amendment) Act in 1992. Until the Amendment, local governments in India were organised on the basis of the '*ultra vires*' principle [beyond the powers or authority granted by law] and the state governments were free to extend or control the functional sphere through executive decisions without an amendment to the legislative provisions. This is an initiative made to improve the performance ability of urban local bodies, so that they are able to discharge their duties efficiently.

2.4.2 The important provisions specified in the Act include constitution of three types of municipalities, devolution of greater functional responsibilities and financial powers to municipalities, adequate representation of weaker sections and women in municipalities, regular and fair conduct of municipal elections, and constitution of Wards Committees, District Planning Committees, Metropolitan Planning Committees and State Finance Commissions.

2.4.3 In order to provide the common framework for Urban Local Bodies (ULBs) and help to strengthen the functioning of the local bodies as effective democratic units of self-government. The Act provides constitutional status to "municipalities" which are of 3 types:

i) Municipal Corporation for a larger urban area,

ii) Municipal Council for a smaller urban area, and

iii) Nagar Panchayat-for transitional area (an area which is being transformed from rural to urban area).

2.4.4 The Constitution (74th Amendment) Act, 1992 provides a basis for the State

Legislatures to guide the State Governments in assignment of various responsibilities to ULBs and to strengthen municipal governance. Accordingly, several State Governments have amended their Municipal Acts/Laws/ Legislations, so as to bring these in conformity with the Constitutional Provisions.

2.4.5 Like other responsibilities, ULBs are responsible for all DM efforts. They have to be specially geared up to deal with urban flooding, especially in terms of early warning, preparedness, mitigation, rescue, relief and restoration. They will prepare City DM Plan in consonance with the Guidelines of NDMA. As the agency is responsible for administering the techno-legal regime, they will have a very critical role to play in mitigation.

2.4.6 Management of urban flooding is the responsibility of the ULB at local level. The state government may also take various schemes/ programmes which have impact on urban flooding. However, the role of ULBs is crucial in the management of urban flooding in their respective cities/towns.

2.5 Urban Development Authorities

2.5.1 Urban Development Authorities (UDAs) have been set up in the states for the purposes of planning, coordination, supervising, promoting and securing the planned development of the area under their jurisdiction in view of rapid urbanization. Some cities like Mumbai and Bengaluru have established Regional Development Authorities while Hyderabad has a Metropolitan Development Authority.

2.5.2 The main functions of the Urban Development Authorities include preparation of development and investment plan and prioritization of the implementation such plan, to undertake execution of projects and schemes as per the said plan and/or through action plans for any sector or area in their jurisdiction, to act as an apex body for coordination and execution of the projects or schemes for the planned development and to coordinate the development activities of various local authorities and departments in the area besides others including providing alternative areas for rehabilitation of persons displaced by projects and schemes which provide for such requirements, etc. They also allocate finances based on the plans and programmes of the local bodies for undertaking development of amenities and infrastructure. They also have a role in enforcing the techno-legal regime.

2.6 Cantonment Boards

2.6.1 Many cities in India, such as Ahmedabad, Belgaum, Bengaluru, Ambala, Kanpur, Bathinda, Delhi, Pune, Sialkot, Secunderabad and Rawalpindi, contained large cantonments of the former British Indian Army. While in the 18th and 19th century cantonments in India were viewed as semi-permanent, by the turn of the 20th century they became permanent garrisons and today many of them have large civil areas with high population densities as they have fully merged with the contiguous municipal areas.

2.6.2 India currently has 62 cantonments in 17 different states. Each cantonment is administered by a Cantonment Board. Cantonment Act of 2006 was enacted with a view to impart greater democratisation, improvement of their financial base to make provisions for developmental activities and for matters connected therewith or incidental thereto.

2.7 Notified Area Councils

2.7.1 The General administration is managed by a council which elects its chairman and vice-chairman. The resolution passed by the councils are executed by the Executive Officer, who is an officer deputed by the state Govt. The financial resources of the National Area Councils (NACs) are mainly derived from various taxes within the urban area and the grants received from Govt. The council discharges the duties, as provided under the Orissa Municipality Act, 1910 with regard to finance, public health, public works, education and any other special subject relating to the purpose of the Act. Executive Officer with the supporting staff carries out day-to-day administration.

2.7.2 There is a Special Planning Authority playing active role in urban planning and administration. This organisation looks after urban regional planning for development of the urban area. Besides, it also acts as the executing agency for area development programmes in infrastructure and social service sectors.

Actions recommended for ULBs in these guidelines will be applicable to all Cantonment Boards, Notified Area Councils, wherever they exist and Metropolitan/Urban Development Authorities (as applicable).

3 Early Warning System and Communication

3.1 Overview

3.1.1 The management of urban flooding is an emerging subject, and as such it has to be treated holistically in a multi-disciplinary manner. There are many issues that need to be considered in order to develop sound, reliable and most representative UFDM strategies. A significant part of this management framework is dependent upon the use of science and technology for improved monitoring, modelling/ forecasting and decision-support systems. One way of improving the preparedness for urban flooding is by setting up a vulnerability-based geospatial framework to generate and analyse different scenarios. This will help in identifying and planning for the most effective/ appropriate actions in a dynamic way, incorporating day-to-day changes that take place in urban areas, with the potential to alter the vulnerability profile.

3.1.2 There is an urgent need for reliable and accurate temporal and spatial data at the local level on real-time basis for enhancing early warning using robust computer models as it is the most basic pre-requisite.

3.2 Data Networks for Monitoring and Early Warning

3.2.1 Information from national monitoring networks is often insufficient for local authorities to evaluate flood risk at the local scale. Often, the network density is insufficient and national network stations are situated according to hydrological and meteorological needs. However, to meet the needs of urban flood warnings, rainfall measuring stations have to be situated locally and densely, based on land development, terrain, watershed, catchment geometry, etc. For these reasons, many countries have established local monitoring networks in addition to their national networks in coordination with National Meteorological and Hydrological Services (NMHSs).

3.3 National Hydro-meteorological Network

3.3.1 Currently, CWC maintains a network of 878 stations across the country for collection and analysis of river basin scale data. For expeditious data collection on 24X7 basis, CWC has installed 55 hydrological stations in Chambal and Mahanadi basins; 168 stations, covering Godavari, Krishna, Mahanadi, Yamuna, Damodar and Brahmaputra basins. During the XI Plan, CWC has proposed to install additional 222 new stations in the country for which the locations are under identification.

CWC should maximize the real-time hydro-meteorological network to cover all the urban centers in support of the emerging priorities in

dealing with urban flooding. The requirement will be assessed taking into consideration all cities/ towns which are particularly located on river banks, upstream and downstream of major and medium dams and island cities. Based on that assessment, CWC will initiate the process to prepare a plan and implementation strategy to seek the support of the government for commissioning such hydrological networks during the XII 5-year plan on priority.

[Action: CWC, MoUD and States/UTs]

3.4 National Meteorological Network

3.4.1 IMD is the custodian of rainfall data in India. Other rainfall observing authorities normally exchange rainfall data with IMD for storage and processing for future use. Catchment-wise daily/hourly rainfall data are collected and archived for various applications by the IMD at its NDC, located at Pune.

3.4.2 As a part of the modernization plan, IMD will establish about 3800 satellite-linked Automatic Rain Gauge (ARG) stations, 1170 Automatic Weather Stations (AWS) and 55 DWR for 24X7 monitoring of weather in real-time with the state-of-the-art observational and communication technology support infrastructure. During 2010-2012, IMD is in the process of establishing 1350 ARGs, 675 AWSs and 12 DWRs. Real-time reception of data from these telemetry networks will facilitate nowcasting of high intensity rainfall. On the other hand, numerical models can provide Quantitative Precipitation Estimate (QPE) and Quantitative Precipitation Forecast (QPF) at grid points and with lead time of 2-3 days. The data from ARGs/AWSs and grid point QPE/QPF can become useful input for distributive rainfall runoff and urban hydrological models.

3.5 Regional Networks

3.5.1 Currently, the following local scale networks of AWSs and ARGs have been set up and are functional for serving various applications:

i) Narmada Control Authority – 90 ARGs,

ii) ISRO South Network around SHAR Centre – 200 AWSs,

iii) ISRO Network over NE India – 80 AWSs,

iv) Karnataka State Rainfall Monitoring Network – 700 ARGs (under further expansion), and

v) Andhra Pradesh State Rainfall Monitoring Network – 1200 ARGs (Under Commissioning).

3.6 Local Networks for Real-Time Rainfall Data

3.6.1 Traditionally, point rainfall data has been used in the calibration of models, as well as for analysing the past flood events and their associated hydrological characteristics at the river basin scale. In an urban scenario, it will be difficult to have a good length of historical data available, covering the urban catchment/ watershed particularly in the required density. However, every effort should be made to start obtaining all such available data for building a most representative data of the urban environment to the extent possible.

3.6.2 Lack of spatial and temporal rainfall data over urban areas on a real-time basis is

a very critical gap. Therefore, establishment of local networks for real-time rainfall data has to be accorded the highest priority. This will be immensely useful for much improved early warning, resulting in better response and management of urban flooding. Such rainfall data will also enable robust designing of urban drainage infrastructure in future. In UK, the recommended rain gauge density for urban areas is 1 ARG per 4 sq km while in Malaysia, it is 1 ARG per sq km. However, the area covered by all 2325 class I, II and III cities is about 54274.59 sq km and also total no. of rain gauge stations required to cover all these cities/towns on the basis of 1 per 4 sq km will be about 13569.

Table 3.1: Status of Local Networks for Real-Time Rainfall Data

S. No.	City	Area in sq km	AWS/ARS	Ord Rain Gauge Stations	Proposed/ Installed*	Requirement (1/4 sq km)
1.	Delhi	1483.00	11	6	30	371
2.	Greater Mumbai	603.00	2	2	35* 65	151
3.	Ahmedabad	190.84	1	1	7	48
4.	Bangaluru	226.00	1	4	-	57
5.	Chennai	176.00	1	3	30	44
6.	Kolkata	197.54	1	2	-	49
7.	Hyderabad	625.00	1	2	150	156

Installation of 35 automatic weather stations (rain gauges) after 26 July 2005 floods in Mumbai

On 26th July 2005, Mumbai suffered severe flooding due to 944 mm rainfall in 24 hours recorded at Santa Cruz observatory at Mumbai airport. According to the Government of Maharashtra, over 60 % of Mumbai city was inundated to various degrees. At that time, there was no reliable real-time rainfall forecast mechanism and IMD was unable to issue advance warnings due to the lack of state-of-the-art equipment like tipping bucket rain gauges, etc. Thus, disaster managers had no means of knowing the spatial or temporal variation of rainfall in real-time. To improve the response and determine the spatial and temporal variation of rainfall in real-time, a network of 35 weather stations with tipping bucket rain gauges has been setup in the city by the MCGM and Indian Institute of Technology Bombay in June 2006. Majority of them are installed on the roof of the fire station control rooms. These rain gauges have been programmed to give rainfall intensity in realtime (every 15 minutes) to the emergency control room at MCGM headquarters through internet. The average rain gauge density is 1 per 16 km^2 and inter-station distances ranges from 0.68 km to 4.56 km. This network has enabled monitoring of rainfall in real-time and has been of immense benefit to disaster managers for mobilizing rescue and relief to the flood affected areas during the heavy rainfall since 2006. An automatic Doppler flow gauge has also been set up in the upstream reaches of Mithi River to measure the flow levels and issue early warnings. IMD is also in the process of setting up a DWR very shortly.

i) IMD will set up a 'Local Network Cell' in the IMD headquarters,

ii) Local Networks with ARGs will be installed in all 2309 Class I, II and III cities and towns with a density of 1 per 4 sq km. Class I cities will be covered by the end of 2012 and the rest by the end of 2015,

iii) The density will be further increased to 1 per sq km, based on the experience gained in urban flood management,

iv) The sampling of rainfall should be uniformly fixed between 5 to 15-minute interval (depending upon topography) to capture the high intensity rainfall data which is crucial for early warning, better response actions, future drainage design, and

v) Emergency Operation Centres (EOCs) will be set-up by the ULBs and connected to the ARG network.

[Action: MoUD, States/UTs, IMD, CWC and ULBs]

3.7 Doppler Weather Radars

3.7.1 DWRs can play a very important role in providing a lead time of 3 to 6 hours for monitoring all developing high impact rainfall events at the local scale and contribute to effective urban flood emergency response management. The DWR has the capability to identify the zones of severe thunderstorm/ rainfall in urban areas by closely monitoring the movement of cloud bands.

3.7.2 The data sets from DWR are available in fine temporal and spatial resolution which is critical for understanding, monitoring and nowcasting (very short-term warning) of severe weather events in near real-time, particularly, in the estimation of rainfall rate and its accumulation. The rainfall forecast from the DWRs will be calibrated and fine tuned with real-time rainfall data from the network of ARGs set up in cities and towns. Mosaics of rain rate and accumulated quantum of rainfall generated in real-time from adjacent DWR stations, when established, will enhance the warning time scale of developing high intensity rainfall events in the vicinity of urban environments.

3.7.3 The advanced meso-scale numerical weather analysis forecast systems that can be configured exclusively for megacities are capable of assimilating AWS observations from the local networks and DWR products viz. radial velocities and winds generated on continuous basis. At present, 7 DWRs are operational at Delhi, Hyderabad, Kolkata, Visakhapatnam Machlipatnam, Sriharikota and Chennai. IMD is is in the process of commissioning additional DWRs at Agartala, Bhopal, Goa, Karaikal, Kutch, Lucknow, Mohanbari, Mumbai, Nagpur, Paradip, Patna and Patiala by 2012.

i) DWRs will be calibrated with real-time rainfall data from the local networks,

ii) City/ town maps will be incorporated on the DWR images,

iii) Cities/ towns will be sub-divided on the basis of watersheds and a protocol will be developed for forecasting rainfall in urban areas on the basis of watershed,

iv) IMD and MoUD will work out a strategic expansion of DWR network in the country on priority basis to cover all urban centres with specified timelines, and

v) An appropriate redundancy plan for radar coverage of local systems with shorter radial coverage (30-50 Km), using either 'C' or 'S' band radars will be worked out by a national level Standing Advisory Committee to guide suitable urban flood monitoring mechanisms.

[Action: IMD and MoUD]

3.8 Data Integration and Sharing

3.8.1 It has been emphasized that the data collection and integration is a very important exercise for the organization entrusted with the responsibility of integrating multi-agency/sensor rainfall and weather monitoring networks. Therefore, it is essential that these issues are addressed appropriately, so that reliable and good quality data becomes available to the local organizations for effective design of urban flood management systems.

It is essential to design and strengthen local hydro-meteorological data networks to cater for the needs of urban flooding holistically. Coordination mechanism will be established among all agencies for deriving maximum benefit from the efforts of each individual organization.

[Action: IMD, CWC, MoUD, States/UTs, and ULBs]

3.9 National Hydrological Information System

3.9.1 The real-time availability of rainfall information from heterogeneous networks operated by various national/regional/local scale agencies provides an opportunity to integrate and generate a most representative rainfall analysis for utilization in UFDM models. All necessary interfaces will be developed to fuse the information for a comprehensive rainfall scenario, developing with updates every 15 – 60 minutes depending upon the rainfall intensities/ events.

3.9.2 Objectives

i) Serve as an access point to a distributed network of national, state and other local (surface water / ground water /irrigation) agency hydrological databases,

ii) Reduce confusion about water data and lessen the chance of misinterpretation,

iii) Simultaneously access water data from many databases, without having to know about the database they are connecting to or how to connect to it, and

iv) Make the release of data in a more efficient and simple fashion, based on an agreed national standard.

3.10 Sensor Web Development – A Service-Oriented Architecture Approach

3.10.1 Sensor webs will have to be dynamically configured to

i) Accept inputs from other sensor systems,

ii) Interact with the available communication environments, based on what they detect or are tasked to perform,

iii) Collect observations and model results in real-time,

iv) Dynamically acquire and fuse data from models, satellite and *in situ* sensors,

v) Validate data observations in near real-time,

vi) Provide intelligent sensor control feedback to enable real-time sensor tasking, and

vii) Enable discovery of, and access to, sensor web components and services.

3.10.2 Building an Underlying Sensor Web Flow

3.10.2.1 Having established robust sensor level service architecture for accessing and processing multiple web-based data sources of various rainfall monitoring networks to account for various UFDM tasks:

i) 24X7 event monitoring (network of rain gauges, monitoring systems),

ii) Urban Flood Hazard Mitigation Models to predict potential events,

iii) Event detection or model prediction triggers for near real-time sensor observation task,

iv) New observation and improved forecast to feed DM portals, and

v) Fuse data products and identify mismatches where calibration is needed.

A dedicated high bandwidth communication channel is to be built, for ensuring smooth underlying sensor web flow of all available information and products.

[Action: DIT and SWAN]

3.11 Infrastructure and other Baseline Data

3.11.1 In addition to the hydro-meteorological data, a large amount of data on infrastructure and other related items is also required. In present-day context, geospatial technologies and Geographical Information System (GIS) tools can be very valuable and indispensable to provide a Spatial Database Infrastructure (SDI), that is, ready to use IT-based solutions for managing urban flooding. Such SDI is facilitated by the space-based platforms like high resolution data from CARTOSAT series of satellites and geospatial technologies like ALTM, GIS, and Global Positioning System (GPS). These tools help in capturing, integrating, visualizing (modelling) diverse and large scale datasets. The tools also assist in building query-based information systems between varied features and objects of interest along with integration of bio-physical and socio-economic data to strengthen Decision Support Systems (DSSs).

3.11.2 In City/Town Development Plan, monitoring and management of various details of terrain such as elevation, relief, slope/gradient and aspect, in addition to other surface details such as buildings (planimetry and height), infrastructure, vegetated areas and surface drainage details are required. The Digital Elevation Model and Digital Terrain Model (DEM/DTM) details would not only help to delineate the macro and micro inundation/flooding of low-lying catchment areas, but also to measure the built up area footprints and impediments while calculating the surface runoff as indicators for refining the urban flooding models. The terrain DEM can be integrated with other infrastructure details like road/street, rail network, public utilities/facilities such as water supply, sewer/stormwater lines and other communication networks.

3.11.3 Spatial distribution, extent and geographic location of different land use footprints would also be required for urban planning. Different land use details should pertain to residential (housing), commercial, public/semi-public, industrial, recreation areas, etc. within the urban limits. Land cover should include details, such as vegetated/ tree covered area, garden/parks and vacant/ open land, not only within urban limits, but also in the urban fringes falling within the watershed. Water bodies, such as tanks/lakes are necessary because they would act as pockets of areas to absorb/store and also minimize the surface water flow during flooding. Surface or natural drainage such as small streams would allow carrying flood waters to nearby bigger streams/ rivers or tanks.

3.11.4 Landform or geomorphologic features within and outside the city would provide insight about the surface expressions of the terrain with respect to its form of materials and processes involved in developing them, for example, flood plain areas close to the proximity of rivers. Landforms also manifest with respect to geological and lithological rock types and structures. Rock types would enable to provide an understanding of the hardness or softness of the terrain which is important while planning construction in towns and cities. Soil information about its cover, texture and depth would be helpful while planning the foundation of buildings, stormwater drainage and sewerage networks.

i) Data models will be built for urban infrastructure, involving geospatial approach with due procedures for data standardization, collation, quality check and annual updation, and

ii) Institutional mechanism will be evolved to share data/information with the institutions and other concerned authorities at local level. Information should be shared with states and vulnerable cities under the overall architecture of NUIS.

[Action: MoUD, NRSC, SoI, SRSACs and ULBs]

3.12 Flood Early Warning System

3.12.1 Meteorological forecasts prepared by IMD, largely include a description of the current and forecasted meteorological weather situation, supplemented by information on the anticipated rainfall, temperature, wind velocity, etc. generated by Numerical Weather Prediction (NWP) models. They are prepared by weather forecasters for larger regions.

3.12.2 Nowcasting systems with ultra-short-term forecasts at 5 to 30 minutes with all supporting tools for weather forecasters will be used for operational practice in the near future. Urban area hydrological forecasts will be worked out for relatively smaller urban sectors and also covering large-scale suburban areas for rendering effective local scale urban flood warnings. Efforts are to be made for the development/calibration of hydrological models on a watershed scale. The connection between the precipitation thresholds, leading to the reaching of dangerous levels in the sections controlling small urban sectors with torrential rainfall regime, will be established by correlating the characteristics of high flood with its triggering factors (balance between likely runoff versus drainage). On the basis of these correlations, there can be pre-established thresholds of the precipitation characteristics

(amount, duration, etc.), which can cause local urban flooding.

3.12.3 Interpretation of the meteorological and hydrological situation on continuous basis by the ULBs is critical for effectively responding to the emerging flood scenario.

3.13 Operational Support

3.13.1 The EOC of the ULB will be the nerve centre for all DM related activities. They will be equipped with the state-of-the-art facilities. In the context of urban flooding the software installed on computers at the EOC should be able to extract rainfall intensity for various durations from an ongoing storm data transmitted in real-time. The suggested durations for the calculations of rainfall intensity are 5, 10, 20, and 30 minutes and 1, 2, 3, 6, 12, 24, 36, 48 and 72 hours. The database should consist of critical rainfall intensity for each of the durations in a local area based on an analysis of the historical rainfall data. This would be helpful in comparison of the emerging situational rainfall to assess the imminent threat of urban flooding. Ultimately, all this will be displayed in a form that will facilitate the decision making process.

Responsibility for operation and maintenance (O&M) of all equipment set up by organisastions like the IMD/ CWC etc will remain with the respective organisations. Facilities, exclusively setup by the ULBs, will be operated and maintained by them. It will be important to have a dedicated establishment at local levels for this purpose.

[Action: IMD, CWC, States/ UTs and ULBs]

3.14 Measurement of Flood Levels

3.14.1 While detection of an imminent flood event based on real-time rainfall data is useful with an Early Warning System (EWS), it may not always be possible to use it in certain locations and/or circumstances. It is possible that the low-lying areas and/or downstream regions in a watershed are not experiencing any rainfall but the rainfall that occurred in upstream stretches results in the movement of flood waters from upstream to downstream reaches. In such situations, real-time measurements of water levels at key locations in the entire watershed can be very important. A pre-analysis of the existing water level data and associated flooding in downstream reaches in the drainage system should be used to determine 'critical water levels' at key locations in the drainage system. As soon as the observed water level at one of the key locations crosses a certain fraction of the 'critical level', an imminent flood threat would be assumed to be constituted.

3.14.2 The input data observed in real-time collected at the EOC from the observation network must be corrected for any errors and/ or inconsistency in them. This is because any error in the data gets propagated through the mathematical models resulting in erroneous flood forecasts, which may lead to an erroneous flood management response being implemented.

3.14.3 The Flood Early Warning System (FEWS) for coastal areas also needs data on sea water level in the form of tidal data in addition to the hydro-meteorological data depending on the hydrological setting of the area.

State-of-the-art automatic water level recorders must be installed throughout the drainage network of the watershed, which may sometimes extend beyond the administrative boundary of the ULB.

[Action: States/UTs and ULBs]

3.15 Decision Support System

3.15.1 Once the flood forecasts have been generated, these can be used to characterize the flood severity and implement the associated flood management plan. The severity of the flood can be characterized, based either on the recently observed data in real-time or the flood forecasts generated from mathematical models.

3.15.2 A five-stage flood management decision support system is suggested. Depending on the combination of various climatic and hydrologic variables involved, a flood index of 'None', 'Minor', 'Moderate', 'Major', and 'Severe' can be determined as shown in Table 3.2.

Table 3.2: Flood Management Decision Support System

S. No.	Category of Flood	Warning	Impact/Action
1	None	No threat of flood	• normal functioning of the urban system
2	Minor	Minor flooding in some areas	• causes some inconvenience to the public
3	Moderate	Inundation of low-lying areas	• may not require evacuation of houses • disruption of roadways but not railways and airports
4	Major	Inundation of large areas	• requires evacuation of houses • wider disruption of rail, road and air traffic
5	Severe	Large scale inundation of many parts of the cities	• needs complete evacuation of houses and businesses • towns and cities cut off from other parts of the country • major disruption of rail, road and air traffic

3.15.3 The whole system has to operate at emergency level under a severe flooding situation. Associated with each flood index is a flood management strategy with well-defined standard operational procedures (SOPs) with regard to the functioning of various units of ULBs. These are 'Normal', 'Watch', 'Alert', 'Warning', and 'Emergency' levels of flood intensity respectively.

The ULB will be responsible for developing step by step procedures and actions to be taken under each flood management strategy. Once the flood has been characterized, the associated flood SOPs will be immediately initiated.

[Action: States/UTs and ULBs]

3.15.4 The main step in characterization of a flood is to compare the rainfall depth and/

Table 3.3: Illustrative Flood Characterization and Associated Flood Management Decision

S. No.	D-Hr Rainfall Depth (mm)	Flood Level at Location X1 (m)	Flood Index	Flood Decision
1.	< R2L	< FL2L	None	Normal
2.	Between R2L and R2U	Between FL2L and FL2U	Minor	Watch
3.	Between R3L and R3U	Between FL3L and FL3U	Moderate	Alert
4.	Between R4L and R4U	Between FL4L and FL4U	Major	Warning
5.	> R4U	> FL4U	Severe	Emergency

or flood levels at key locations in the drainage basin (observed or forecasted) with the critical values of these variables that are pre-decided, based on local conditions. Table 3.3 presents a guideline for sample flood characterization and management system. The flood characterization and corresponding decision to be taken are based on only two factors, namely, rainfall depth for a D-hour duration and flood level at a key location. Here, D is the duration of rainfall, considered important in the area that is critical in producing intense storms and associated flooding. Normally, duration should be taken at least equal to the time of concentration of the catchment under consideration.

3.15.5 A finer or coarser division of the range of variables, flood index, and associated flood management policy may be adopted in a local area, if required. It is to be noted that the historical rainfall and flood level data in the catchment at key locations will need to be analyzed to prepare a similar table for each key location in the drainage basin. The values of lower and upper bounds in each class (e.g. R stands for rainfall and FL stands for flood level; R2L, FL2U, etc.) will need to be determined, based on local conditions and analysis of historical data. It is possible to extend the scope and size of this table depending on the additional data available in the region in terms of other climatic variables and/or remote sensing images. For example, a column can be added in Table 3.3 to represent the distance of a thunderstorm cell from an urban area, detected by a radar/satellite image. Lesser the distance, higher would be the flood risk.

3.15.6 Once Table 3.3 has been prepared, the knowledge about flood characterization and management strategy can be embedded in the flood management DSS in the form of IF THEN type of rules to build the knowledge base. This will require the use of advanced technology such as expert system computer software. The knowledge base and DSS must be validated before being put into use. Validation of the DSS can be carried out using historical data to generate flood management response strategies along with SOPs, and analysing them for their suitability, feasibility and practicability/ applicability. The DSS should also have features to automatically generate logistic requirements for performing resue and relief operations like number of people to be evacuated, number of vehicles required for evacuation, capacity of flood shelters and relief centers, food and water needs for maintaining a relief centre, etc.

3.15.7 An important feature of the flood

management DSS is the conversion of the flood forecast into flood hazard mapping (FHM) in the urban watershed/ catchment. For example, if the rainfall intensities or flood levels exceed certain threshold levels, it would result in flooding certain areas in a locality, after a certain amount of time. The knowledge about potential areas that will get affected, and after how much time, plays a key role in the early flood warning system.

ULBs will be responsible for converting the real-time data or forecasted information into flood hazard maps and available time.

3.15.8 Knowledge and experience from past flooding events can be integrated with the rainfall, flood level, and other data to prepare look-up tables. For example, rainfall intensities and flood levels at key locations in the catchment would result in flooding, in which area and after how much time, can be recorded in tables or in the knowledge base of the DSS.

This information can be collected from residents and historical flood events and such data sets will be updated soon after a new urban flood event that develops from time to time.

3.15.9 The EWS operators can look up to the tables to arrive at a possible flood warning/alert/watch decision. Alternatively, mathematical models, based on hydrological and hydraulic principles, can be developed using topographical information of the area. These tools can be integrated in GIS environment to obtain graphical representation of the potential flooding.

Inputs from scientists and technologists, who are key stakeholders in an EWS, will be sought in developing flood forecasts, flood hazard mapping, and development of flood characterization and management policies.

3.16 Flood Alert System

3.16.1 Once a flood warning is generated from the DSS, it needs to be communicated to general public in an effective and understandable manner. The warning must be issued through government officials. Dissemination of flood warnings must be carried out, using a wide range of latest technologies. The flood warnings can be simultaneously issued through radio, television, mobile phones and SMS messages, put on the official websites, of all government agencies, emergency services, media, etc. A schematic version of integrated early flood warning system is shown in Figure 3.1.

3.17 Road Map

3.17.1 Total flood protection is neither possible nor justifiable. Therefore, flood protection is usually geared towards reduction of the impact of the flood loss and flood liabilities. The ultimate objective of urban flood management is to provide ways and means to deal effectively with the possible flooding in urban areas.

3.17.2 Every watershed/catchment is unique and needs to be analysed to identify drainage problems under present and changing hydrologic conditions. The hydrology should then be analysed with full development of the watershed/ catchment, so as to identify the improvements necessary to serve future developments. It is desirable to have an integrated approach that recognizes drainage system complexity and interconnectivity of its elements such as stormwater drainage, water supply, wastewater, water pollution control, water reuse, soil erosion, solid waste management, etc. The approach should also be sustainable which means that the human needs of the present should be met without undermining the resource and ecological base of the future generations.

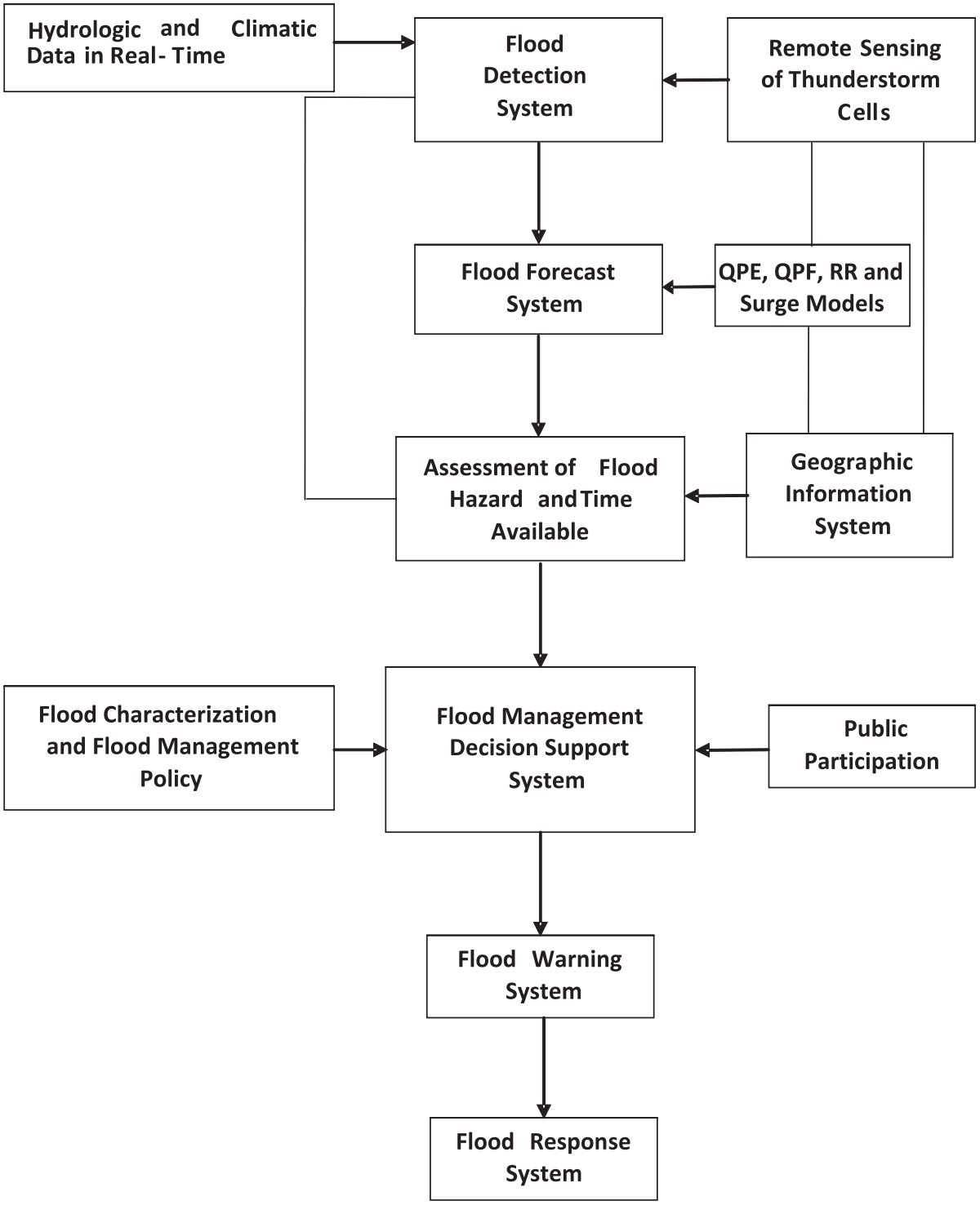

Figure 3.1: Schematic Version of an Integrated Flood Early Warning System

3.17.3 The flood preparedness plan needs to be put in position which shall have many sub-components, viz. flood forecasting and warning, land-use change implications, climate change implications, and alternative development plans that are in the realm of mathematical models. As already discussed, the pre-requisite for using such mathematical models is the availability of good and reliable data to be available in optimal space and time distribution.

3.17.4 Early warning systems are expected to generate time-sensitive information about flood risk which needs to be communicated to the emergency responders and other stakeholders about communities at risk. In case of flash floods, such systems play a very crucial role in saving lives. Although in most cities it is difficult to reliably forecast floods caused by exceeded drainage capacities, it is generally practical to produce warnings in the case of riverine floods. However, the installation of hydrological and meteorological monitoring and forecasting systems to generate such information at the local scale is the first step in the formation of a comprehensive urban flood EWS. The key challenge is to convert forecast information into practice by setting up workable systems of warning dissemination that enable people to avoid the worst. Success of such a system is closely related to people's knowledge of flood risk and their familiarity with emergency response procedures. Only then will they be able to react appropriately to warnings.

3.18 Establishing Technical Umbrella for Urban Flood Forecasting and Warning

3.18.1 There is an increasing trend of urban flooding in the country. Urban flooding events have the potential of severe impact on our cities and towns, which are emerging as the economic centre. These can lead to serious local, national, regional and global implications of extremely severe proportions. Enough has not been done in the past to evolve strategies for effective UFDM. Even a simple thing as the knowledge of "how much it is raining and where" eludes us, as we do not have local network of rainfall gauges, even though they are not prohibitive in terms of technology, cost or availability.

3.18.2 Though we have immense wealth of technical knowledge in the country, it has not converged into UFDM capabilities. This is a clear gap that needs to be addressed on priority basis, particularly, at the state and the local levels. Even at the national level, with the designation of the MoUD as the nodal ministry for urban flooding, UFDM will have to be brought into sharper focus. Taking all these factors into account, it is imperative to establish a Technical Umbrella with a standing and supportive mechanism at the national and the state level to ultimately make it sustainable at the ULB level.

At the National Level

A Standing Mechanism will be established for continuous guidance and support to the State and Local level initiatives to build and establish an integrated town/city-specific UFDM Framework. It will be driven by NDMA and MoUD with representatives from related Ministries/ Departments /Agencies, States, and experts from IITs, other Institutes of national importance and service/ professional bodies, as a part of this mechanism to shoulder the responsibility for building an effective UFDM at the local scale with committed/continued technical support and operational infrastructure.

[Action: NDMA, MoUD IMD, CWC, SoI and NRSC]

At the State Level

State Nodal Departments will establish a State Level Guidance, Monitoring and Approval Mechanism for UFDM for building Effective Capacity Development/ Manpower Training/ Observational Network Design and Operational support. The ULB Scale Customization / Operation/ Upgrade and Update activities of UFDM will be shouldered by a Consortium of Local Level Technical Institutions (NITs, Engineering Colleges, etc.) for establishing GSM/WAN telemetry based ARG/AWS network; customization/testing/operation of urban flood EWS; customization of all necessary spatial and non-spatial data for building DSS for UFDM.

ULBs will extend all necessary administrative/financial/logistical support for the designated consortium of local level technical institutions to commission and operate the UFDM systems with due technical support/ manpower development teams on sustainable basis. ULBs need to organize an institutional back-up through developing appropriate MoUs with those technical institutions identified for this task.

[Action: MoUD, States/UTs, SRSACs and ULBs]

4 Design and Management of Urban Drainage System

4.1 Overview

4.1.1 Floods are caused by weather phenomena and events that deliver more precipitation to a drainage basin than can be readily absorbed or stored within the basin. Drainage basins can be rural (natural) or urban (man-made), the latter commonly being much smaller than the former. Urban floods can have both area-wide and local origin. Urban areas have high densities of population and infrastructure. Drainage systems are topographically small and the time of flow to the nearest drain or channel is quite short, typically of the order of a few minutes. As a result of this, when it rains on the city surface, three main effects are seen:

i. Peak rate of flow increases by upto 8 times,

ii. Shorter (faster) time of flow (3- 45 minutes) caused by increased velocity of runoff due to channel improvement, and

iii. Runoff volumes increase by upto 6 times.

Rapid urbanisation has resulted in increased impermeable surfaces in the form of pavements, roads and built-up areas, thereby reducing the infiltration and natural storage.

The magnitude of such increases depends on many factors, such as the frequency of storms, local climate and condition of the catchment surface, etc.

4.1.2 The post-development runoff peak can be reduced by structural measures. Structural measures are physical in nature and include redesigning the existing drainage system, or by providing suitable interventions in the form of storage at suitable locations in the upstream catchment. The storage reduces the peak, but not the volume of runoff, which contributes to increased runoff flows over extended time periods. Non-structural measures strive to keep people away from the flood waters by means of EWS and other mitigation measures.

4.2 International Status

4.2.1 The World Meteorological Organization (WMO) presented a comprehensive review of the management of urban rainwater, urban drainage and river flooding in cities in a publication "Urban Flood Management" (March, 2006). This was addressed to decision makers, professionals working in the area of urban environment as administrators, legislators, engineers, architects, geologists and others. Subsequently, WMO published another document on "Strategy and Action Plan for the Enhancement and Cooperation between National Meteorological and Hydrological Services for Improved Flood Forecasting" (December, 2006). The document

emphasizes the improvement of the capacity of National Meteorological Services (NMSs) and National Hydrological Services. Also, under a joint initiative with the Global Water Partnership (GWP), the WMO has formulated the Associated Programme on Flood Management (APFM) to promote the concept of Integrated Flood Management. Under this initiative, a technical document on "Urban Flood Risk Management: A Tool for Integrated Flood Management" has been published (March, 2008). The document describes the various aspects of an integrated management process, such as risk assessment, planning and implementation of measures, and evaluation and risk reassessment.

4.2.2 Most countries have dedicated codes and manuals for stormwater drainage design. USA has the "Urban Drainage Design Manual", published by the Federal Highway Administration of the US department of transportation (2009, 3rd edition). Moreover, each state/ county has brought out its own manual and, in many cases, even individual cities have their own city-specific manual. These are updated regularly, some on an annual basis. European countries are now following a common code on "Drainage and Sewer System Outside Buildings". In Australia, the "Australian Rainfall and Runoff Manual" (2008, 4th edition) is used in the various states of Australia, while the north-eastern state of Queensland, which experiences the monsoon type rainfall, has its own stormwater drainage manual. The national meteorological agencies in most countries have developed Intensity-Duration-Frequency (IDF) curves from the rainfall records and provide these to the design engineers for carrying out urban drainage design.

4.2.3 For better urban flood management, many cities like Bangkok, Tokyo, Singapore, etc., have developed a real-time satellite-radar-rainfall based warning system with adequate number of radars and ARGs. Regular desilting of drains is also carried out on a time bound schedule in many important cities.

4.3 National Status

4.3.1 The Central Public Health and Environmental Engineering Organization (CPHEEO), under the Ministry of Urban Development (MoUD), GoI, has published the "Manual on Sewerage" (1993). This manual has given extensive guidelines for sewer design, but has only a small section for storm drainage design. However, even this was not being followed by many cities in the past. This manual mentions a uniform design rainfall intensity of 12-20 mm/h for all cities and does not take into account the spatial distribution of rainfall over India or within the cities. Systems designed with these values will cause flooding, whenever rainfall intensity values exceed 20 mm/h. However, while taking up projects under JNNURM, rainfall data obtained from Self-Recording Rain Gauge stations is followed, which takes into account the rainfall pattern of the cities. MoUD has, in 2008, constituted an "Expert Committee for the preparation of (a separate) Urban Storm Drainage Manual".

4.3.2 The Indian Roads Congress (IRC) brought out guidelines on urban drainage in 1999 (SP-50-1999, IRC). This provides guidance for drainage design for roads, but does not provide design information on rainfall intensities to be adopted for various cities. For example, it mentions that Mumbai drains are being designed for 50 mm/h and Chennai for 25 mm/h, but does not provide guidelines for future planning for other Indian cities.

The comprehensive Urban Storm Drainage Design Manual will be released by 2012. This will take into account current international practices, the specific locations and rainfall pattern of the cities and future needs. This will be updated/ revised as per practice followed internationally.

[Action:MoUD]

4. 4 Drainage Systems

4. 4.1 Drainage systems can be categorized as major and minor systems. The major drainage system comprises of open nallahs/ and natural surface drains, etc. The minor system is the network of underground pipes and channels. The minor system can be categorized into two types: separate and combined. Separate drainage systems consist of two conveyance networks the sanitary sewers (usually underground pipes) conveying wastewater from homes and businesses to a discharge point, while the storm drains (underground pipes or channels) collect water from the rainfall runoff and convey it to a discharge point which is usually a natural watercourse or coastal waters.

4.5 Stormwater Drainage System Inventory

4.5.1 It is observed that a proper inventory of water supply system is maintained starting with details of treatment, pumping, storage and along with the main feeder lines to the smallest domestic connection. Similarly for the sewer lines an inventory is available starting from the smallest domestic connection to the sewer trunk mains for all the areas which are serviced with a proper sewerage system. These are generally essential for O & M besides system upgrading and replacement. However, there are extensive areas which are unserved by the sewerage system and the waste water is discharged into the stormwater drainage systems.

4.5.2 ULBs generally do not keep a systematic and complete inventory, especially of the minor drainage system. As a result of this, it is difficult to plan O & M and upgradation of the system. Even with respect to the major drains, inventories are not maintained with clear delineation, demarcation and details of the cross-sections and slopes. There may be natural formations and man made structures like bridge piers, transmission towers and cables laid across, service utilities like sewers, water supply and gas pipe lines which may reduce the cross-section available for flow. Besides all these, there may be existing encroachments, etc.

i) An inventory of the existing stormwater drainage system will be prepared on a GIS platform,

ii) The inventory will be both watershed based to enable proper hydrologic and hydraulic analysis and ward based to enable coordinated administrative management,

iii) Minor systems should be mapped clearly showing the interconnections with the major system besides the cross connections with sewer lines, and

iv) Major systems will be mapped clearly with delineation, demarcation and details of the cross-sections, slopes, drain crossings including natural formations and man made structures like bridge piers, transmission towers, service utilities and existing encroachments, etc. This should also take into account the sewer discharges.

[Action: MoUD, States/UTs and ULBs]

4.6 Requirements for Urban Drainage Design

4.6.1 There is a need for the development of an adequate and functioning drainage system based on sound hydrologic and hydraulic design principles. The design of an urban drainage system requires knowledge of the catchment area and topography, urbanization details, rainfall intensity, hydrology, hydraulics, etc.

4.7 Catchment as basis for Design

4.7.1 States and cities have political and administrative boundaries. However, rainfall and runoff processes are independent of these, and depend on the watershed delineation. The outline of the drainage divide must follow the actual watershed boundary rather than the administrative boundaries. Each urban area may consist of a number of watersheds. A watershed is the geographic region within which water drains into a stream, river, lake or sea. The watershed may be composed of several sub-watersheds and catchments. The catchment is the area draining surface water to a particular location or outlet point.

Catchment will be the basis for planning and designing the stormwater drainage systems in all ULBs.

[Action: MoUD, States/UTs and ULBs]

4.8 Contour Data

4.8.1 Accurate contours are necessary for determining the boundaries of a watershed/ catchment and for computing directions of flow. Detailed contour maps at required resolution should be prepared for proper delineation of drainage catchments. Mumbai is preparing contour maps of the city at intervals of 0.2 m while Chennai is preparing them for 0.3 m.

Contour mapping of urban areas will be prepared at 0.2 to 0.5 m contour interval for detailed delineation of the watershed/ catchment for planning drainage systems.

[Action: MoUD, SoI, States/UTs and ULBs]

4.9 Rainfall Requirements

4.9.1 For design of a drainage system, the conventional practice is to choose an appropriate, statistically relevant design storm to establish the stormwater flows to be conveyed, based on existing national and international practices. Design storms can be estimated from rainfall data records where available.

4.9.2 Rainfall is the main driver of runoff processes. As discussed in Chapter 1, the frequency and intensity of rainfall in India, not only shows a great variation but the intensity of rainfall also is generally much higher than in many other countries. There is wide variation of rainfall amongst the cities and, even within the city, rainfall shows large spatial and temporal variation; for example, in Mumbai, on 26th July 2005, Colaba recorded only 72 mm of rainfall while Santa Cruz, which is 22 km away, recorded 944 mm in 24 hours. Even isolated high intensity rainfall over a small urban area affects a large number of people due to traffic disruptions besides local flooding. Due to the high variability of rainfall in space and time, rainfall measurements are required at high temporal and spatial resolution from dense rain gauge networks for the adequate design of new systems and/or renovation of existing drainage systems. Up to date IDF relationships need to be used to maintain design standards for new systems and retrofitting/replacement of old urban drainage systems.

4.10 Real-Time Rainfall Data

Real time rainfall data for urban areas should be collected by the ULBs as discussed in detail in Section 3.6 of this document.

4.10.1 Thunderstorm Rainfall Intensity

4.10.1.1 Special consideration should also be given to rainfall caused due to thunderstorms which result in high intensity rainfall in short durations (e.g. 15 mm rainfall in 15 minutes i.e. 60 mm/h). Delhi and many other cities faced severe disruption due to flooding in 2009 and 2010, caused by thunderstorms embedded in monsoon systems which overwhelmed the drainage systems, designed for much lesser values of the rainfall intensity. By the very nature of formation, it is observed that severe thunderstorms, no matter where they occur, result in rainfall intensities of the order of 50-70 mm/h which cause flash flooding. Hence, the frequency of thunderstorms becomes an additional consideration for planning future urban drainage systems.

i) IDF curves will be developed for each city, based on extraction of data from the raw data charts at 15- minutes resolution and from AWS at 5-minutes resolution, and

ii) IDF relationships will be adjusted taking into account climate change impacts and urban heat island effects. At the very least, a trend analysis of short duration rainfall intensities will be carried out and if an increasing trend in the recent years is shown, higher intensities than those provided by IDF relationships will be used for resizing existing systems and design of new systems, especially for critical infrastructure like airports, major roads and railway tracks.

[Action: IMD, States/UTs and ULBs]

4.10.2 Design Flow

4.10.2.1 To protect residential, commercial, industrial and institutional buildings in urban areas, safe management and passage of water, resulting from frequent storm events (hydrologic design aspects) and adequate capacity (hydraulic design aspects) must be considered. In the context of urban drainage, the main objectives of hydrologic analysis and design are to estimate peak flow rates and/or flow hydrographs for the adequate sizing and design of conveyance and quantity control facilities. To estimate peak flow rates, knowledge of the rainfall intensity, its duration and frequency is required for preparing satisfactory urban drainage and stormwater management projects. Due to limited data, statistics and probability concepts are used in hydrologic analysis. Current international practice involves frequency analysis of rainfall intensities, based on extreme value distributions with adjustments for climate change effects. Intensity-Duration-Frequency (IDF) curves are required to be developed for systematic analysis. However, the return period concept has an element of subjectivity. Increasing rainfall intensities induced by climate change, urban heat islands and other factors, will possibly result in varying return periods for a given intensity of rainfall. The rainfall intensity to be used for design will also depend on the time of concentration. Higher the catchment area, higher will be the time of concentration and lower will be the design rainfall intensity, other factors remaining the same.

4.10.2.2 Peak flow rates can be estimated using the Rational Method. However, for computation of water level profiles in the drainage systems or channels/rivers, suitable software for flood routing should be used. The available public domain software are the

HEC-HMS for hydrologic modelling of the watershed, HEC-RAS for river modeling, both developed by the US Army Corps of Engineers and SWMM (Stormwater Management Model) for sewer/ drainage design, developed by the US Environmental Protection Agency.

4.11 Runoff Coefficient for Long Term Planning

4.11.1 Keeping in view the projected rate of urbanisation, it is imperative to consider a 50-year planning horizon. Due to development that is bound to take place during this period, it will be difficult to upgrade the underground drains once they are laid. Therefore, it is recommended that all future drainage plans for urban areas should be carried out, taking these factors into consideration.

All future stormwater drainage systems will be designed taking into consideration a runoff coefficient of upto C = 0.95 for estimating peak discharge using the rational method, taking into consideration the approved land-use pattern of the city.

[Action: MoUD, States/UTs and ULBs]

4.12 Operation and Maintenance

4.12.1 Overview

4.12.1.1 Proper operations and maintenance (O&M) are crucial for any system to be functional to the designed capacity and for its durability as well. Most of the stormwater drainage and sewerage systems suffer to a great extent for want of proper O&M. Both the major and the minor drains are equally affected by this.

4.12.2 Pre-Monsoon Desilting

4.12.2.1 Major drains and nallahs were originally water-ways for rainwater to flow. Therefore, pre-monsoon de-silting of drains had become an annual ritual. However, due to large scale urbanisation and lack of required sewerage systems in place, sewage started getting discharged into these water ways. All the same pre-monsoon de-silting is a major O&M activity. It has been generally observed all over the country that this does not commence and get completed on time and as such even the designed capacities are not operational. As a result of this, even lower intensity of rainfall results in flooding.

4.12.3 Removal of Solid Waste

4.12.3.1 Solid waste disposal and its proper management have significant effects on drainage performance. Most towns and cities have open surface drains besides the road, into which there is unauthorized public disposal of waste. Solid waste consists of domestic, commercial and industrial waste. Besides, unauthorised and illegal dumping of construction and excavation debris at the household and community level are also very common occurrences. Solid waste increases hydraulic roughness, causes blockage and generally reduces flow capacity. Besides, most of these drains carry large quantities of sewerage all year round, effectively resulting in decreased capacity being available for rain-water to flow. In addition, blocked drains may create insect breeding sites and encourage disease transmission. These drains need to be cleaned on a regular basis to permit free flow of water. There may also be instances of pipe bursts, etc.

4.12.4 Removal of Sediment

4.12.4.1 Sediment is present on all urban catchment surfaces and much of this material finds its way into the drainage system. The amount that enters the system is limited

by the degree of street sweeping and the effectiveness of the inlet catch basins or gully pots and their cleaning regime. Management of such sediment is rarely carried out, even in industrialized countries. In developing countries with larger amounts of sediment and weaker urban management systems, the extent and magnitude of sediment in the drainage system can have a significant impact on its performance. As with solid waste, sediments also greatly reduce flows. The duration of local flooding increases proportionately, with the extent to which the cross-section of the channel was filled with sediment. In many cases, the operational practices are poor as clearing up drains is not done from the outlet end particularly in minor drains resulting in very little net benefit.

4.12.4.2 Due to non-availability of adequate flows in the minor drainage systems, frequent deposit of sediments will result and ultimately result in a loss of capacity to accommodate the flows during high intensity monsoon rainfall, thus compounding the existing situation which is far from being satisfactory.

4.12.4.3 Lack of preventive maintenance of minor drains and sewerage systems is also very commonly observed. In some cities, some underground drains are over a 100 years old and are now susceptible to collapses because of age and increased burden due to traffic load.

i) Pre-monsoon desilting of all major drains will be completed by March 31 each year,

ii) Besides the pre-monsoon de-silting of drains, the periodicity of cleaning drains should be worked out, based on the local conditions. The roster of cleaning of such drains should be worked out and strictly followed,

iii) All waste removed both from the major and the minor drains should not be allowed to remain outside the drain for drying, instead the wet silt should be deposited into a seamless container and transported as soon as it is taken out from the drain. In exceptional cases, the silt may be allowed to dry for about 4 to 24 hours outside the drain before transporting the semi-solid silt for disposal,

iv) Completion of work will be certified by representatives of local Residents' Welfare Associations (RWAs)/ Slum Dwellers Associations (SDAs) / Municipal Ward Committee members and Area Sabha members besides third party certification. An appropriate mechanism will be evolved to ensure this,

v) The Manual on Solid Waste brought out by the CPHEEO, MoUD, (2000) will be followed in cleaning shallow surface drains,

vi) The amount of solid waste generated varies from catchment to catchment and depends on the type of locality, population, their affluence, etc. Suitable interventions in the drainage system like traps, communitors, trash racks can reduce the amount of solid waste going into the storm sewers,

vii) Land will also be identified for locating such structures along the drains. The design of such structures will be based on actual field measurements at the proposed site rather than generic values from a single site,

viii) Due consideration will be given to internationally available technology for removal of solid waste from stormwater drains,

ix) De-silting of minor drains will be carried out as part of a regular preventive maintenance schedule. The catchment will be the basis for planning this, as a part of the watershed de-silting master plan,

x) Cleaning of minor drains will be taken up from the outlet end to upstream side.

xi) Ageing systems will be replaced on an urgent basis,

xii) A master plan will be prepared to improve the coverage of the sewerage system so that sewage will not be discharged into stormwater drains, and

xiii) Adequate budget will be provided to take care of the men, material, equipment and machinery. Special funds will be provided for the safety equipment of the personnel carrying out maintenance of underground man-entry sewers.

[Action: MoUD, States/UTs, ULBs]

4.13 Special Design Considerations

4.13.1 Airports

i) Airports are critical infrastructure. Keeping the airports operational under conditions of severe flooding, will be very crucial for rushing emergency supplies. Even in the event of the arterial roads being flooded, helicopters can be used to rush supplies received at the airports to the affected areas.

ii) It is therefore of utmost importance that these will be made flood-proof by providing efficient drainage for a much higher rainfall intensity and using Best Management Practices like provision of holding ponds.

[Action: Ministry of Civil Aviation, States/UTs and ULBs]

4.13.2 City bridges

4.13.2.1 Increasing road networks for the ever increasing urban population has resulted in the construction of a large number of flyovers and bridges. In many instances, due to the shortage of land, the piers of roads and railway bridges are located in major stormwater drains and/or rivers in cities. These are known to cause backwater effects as much as 1 m high and as far away as 5 km upstream thereby resulting in flooding of the upstream catchments.

All future road and rail bridges in cities crossing drains should be designed such that they do not block the flows resulting in backwater effect.

[Action: States/UTs and ULBs]

4.13.3 City road levels

4.13.3.1 Plinth level of the houses was historically defined with reference to the adjacent road level. However, a recent trend that has emerged in many cities is that the roads are being resurfaced without removing the older layer. As a consequence, over the years, the new road levels, in many instances, are now much higher than the approved plinth level of the adjacent properties. This prevents drainage of the houses and during periods of rainfall, stormwater runoff causes flooding of these properties even with lower rainfall intensity.

All road re-leveling works or strengthening/overlay works will be carried out by milling the existing layers of the road and recycling of materials obtained as a result of the milling so that the road levels will be not be allowed to increase.

[Action: States/UTs and ULBs]

4.13.4 Drain Inlet Connectivity

4.13.4.1 It is observed that in many cities, rainwater causes flooding on the road despite the existence of the underground drainage system. It is seen that the inlets to drain the water from the roads into the roadside drains are either not properly aligned or non-existent leading to severe waterlogging on the roads. The provision of a simple connecting element namely, the drainage inlet through which the water can flow from the roadside drain into the underground drain can significantly reduce the waterlogging on the roads.

Inlets should be provided on the roads to drain water to the roadside drains and these should be designed, based on current national and international practices. Indian Standard IS 5961 provides the design details for cast iron grating for drainage.
[Action: States/UTs and ULBs]

4.14 Best Management Practices

4.14.1 Best Management practices (BMPs) are used in USA to describe both structural or engineered control devices and systems to reduce both pollution and runoff from stormwater. On the other hand, Low Impact Development (LID) is also used in the United States to describe a land planning and engineering design approach to manage stormwater runoff through various techniques such as infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. LID is similar to Sustainable Urban Drainage Systems (SUDS), a term used in the United Kingdom, Water Sensitive Urban Design (WSUD), a term used in Australia, natural drainage systems a term used in Seattle, Washington and "Onsite Stormwater Management", a term used by the Washington State Department of Ecology.

4.14.2 More recently, best practices in stormwater drainage has shifted away from one of purely stormwater disposal to stormwater management, incorporating the principles of sustainable development. In this approach, stormwater is regarded as a resource to be managed on a catchment-scale basis including incorporation of the concepts of 'source control'. Table 4.1 classifies the wide range of techniques available.

4.15 Source Control

4.15.1 In source control schemes, stormwater is not immediately discharged but is stored, treated, reused or discharged locally, close to its point of generation. It involves the use of smaller facilities located near the source allowing better use of downstream conveyance systems. Source control includes local disposal, inlet control and onsite detention. Local disposal can be achieved through infiltration trenches/ basins, percolating recharge wells, and porous pavements. Inlet control can be through rooftop storage or parking area storage followed by controlled discharge. On-site detention includes ditches, dry ponds, wet ponds and underground concrete basins.

4.15.2 Source control devices interact with the urban water system and the environment in different ways to conventional systems, mainly beneficially, by:

i) Reducing peak runoff rates leading to lower frequency of flooding,

ii) Recharging soil moisture and groundwater and watercourse base flow augmentation,

iii) Decreasing downstream channel erosion through flow reduction and velocity control,

Table 4.1: Classification of Source Control Options

Option	Examples	Advantages	Disadvantages
Local disposal	Rain gardens, Soakways, Infiltration trenches	Runoff reduction of minor storms Ground water recharge	Capital cost Clogging
	Swales, Lawns	Runoff delay Improved aesthetics Capital cost	Maintenance cost
	Porous pavements/ porous parking lots	Runoff reduction of minor storms Groundwater recharge	Capital & maintenance costs Clogging
Inlet control	Rooftop ponding	Runoff delay Cooling effect on building Possible fire protection	Structural loading Roof leakage Outlet blockage
	Downpipe storage e.g. water butts	Runoff delay Reuse opportunities Small size	Small capacity Access difficulties
	Paved area ponding e.g. gully throttles	Runoff delay Possible retrofitting	Restricts other uses when raining Damage to surface
On-site storage	All types of water bodies Detention ponds	Large capacity Runoff reduction of major storms Ground water recharge Multi-purpose use	Capital and maintenance cost Pest breeding potential Reduced Aesthetics Safety hazard
	Underground tanks	Runoff reduction of storms No visual intrusion Capital cost	Maintenance cost Access difficulties
	Oversized sewers	Runoff reduction of storms No visual intrusion Capital cost	Maintenance cost Access difficulties

Source: Adapted from Gupta, et al, 2010

iv) Reducing pollutant load to receiving waters, and

v) Preserving and enhancing natural vegetation and wildlife habitats in urban areas.

4.16 Rainwater Harvesting

4.16.1 Rainwater harvesting is a form of source control in which water can be converted into a resource. In recent years, due to urbanisation, groundwater recharge has decreased and the peak runoff from rainfall and consequent

flooding have increased. It is therefore necessary that rainwater harvesting should be carried out extensively. This will serve the twin purposes of lowering the peak runoff and raising the ground water table. Many municipal corporations in India have already made rainwater harvesting compulsory. This subject has been dealt with in detail in Chapter 6.

Every building in an urban area will have rainwater harvesting as an integral component of the building utility. ULBs will ensure that this is implemented.
[Action: States/UTs and ULBs]

4.17 Rain Gardens

4.17.1 Rain gardens are part of the LID paradigm for stormwater management that is rapidly becoming recognized by environmental managers and regulators responsible for watershed protection. Rain gardens consist of a porous soil covered with a thin layer of mulch. Various flowering plants, grasses and small plants are planted to promote evapo-transpiraton, maintain soil permeability and infiltration. Stormwater runoff is directed into the facility, allowed to pond and infiltrates through the plant/mulch/soil environment. Basic intention is to create an engineered terrestrial ecosystem which has significant aesthetic value through the use of flowering plants and landscaping that are both attractive and functional, along with a constructed soil/media profile.

4.17.2 Rain gardens capture runoff from impervious areas such as roofs and driveways and allow it to seep slowly into the ground. Rain gardens provide for the natural infiltration of rainwater into the soil, reduce peak storm flows, helping to prevent stream bank erosion and lowering the risk for local flooding. A rain garden receives runoff water from roofs or other impervious (hard) surfaces in the natural environment. The rain garden holds water on the landscape so that it can be taken in by plants and infiltrate into the ground instead of flowing on roads and down a storm drain or drainage network. This also results in marked improvement in the ground water level. The new Hyderabad airport is a very good example of the concept of rain garden developed by the National Geophysical Research Institute.

Concept of Rain Gardens will be incorporated in planning for public parks and on-site stormwater management for larger colonies and sites that are to be developed. People will be encouraged to adopt this concept even for sites already developed.
[Action: States/UTs and ULBs]

4.18 Water Bodies

4.18.1 Urban water bodies like lakes, tanks and ponds also play a very important role in the management of urban flooding by reducing the stormwater run-off by capturing it. In the past there have been many water bodies but over the years their numbers have been dwindling for various reasons. There have been encroachments. There are some instances of reclaiming water bodies and area reclaimed has been used for various activities. It is not only private parties but even governments that have been responsible for such things.

All urban water bodies will be protected. Efforts will also be made to restore water bodies by de-silting and taking other measures. Efforts will also be made to revive water bodies that have been put to other uses. Water bodies will be an integral part of the stormwater system.
[Action: States, ULBs]

4.19 Detention Ponds

4.19.1 Detention ponds, also called holding ponds, will be useful in reducing peak flows and hence the frequency of overflow. Detention may be achieved on the surface or subsurface. Surface detention refers to extended detention basins or dry detention basins (that will be empty after a storm) and wet detention ponds (that retain water above a permanent pool). Flood routing through detention ponds should be carried out for observed events in real-time to enable the determination of time and magnitude of flow at crucial points to facilitate early warning and, if necessary, initiate evacuation procedures.

Urban stormwater management systems will include detention and retention facilities to mitigate the negative impact of urbanization on stormwater drainage.

[Action: States/UTs and ULBs]

4.20 Lined Channels

4.20.1 Stormwater drainage channels (or flood control channels) must behave in a stable, predictable manner to ensure that a known flood capacity will be available for a design storm event. Channel linings should be provided in urban drainage channels to achieve channel stability because most soil erodes under concentrated flow. Linings maybe "flexible" – for example stone pitching (riprap), vegetation, manufactured mats or a combination of these or "rigid" – for example concrete or asphaltic concrete. Rigid linings are capable of high conveyance and high velocity flow and are used to reduce the amount of land required for a surface drainage system, especially in urban areas.

i) Rigid lining will be implemented in high density urban areas where space is a constraint, and

ii) Flexible linings will be provided in medium and low density areas and new urban developments, as these permit infiltration and are environmentally friendly, providing habitat for flora and fauna and are less expensive.

[Action: States/UTs and ULBs]

4.21 Integrated Planning and Interactions

4.21.1 Historically, the main components of urban water systems and the provision of related water services, including water supply, drainage, sewage collection and treatment, receiving water uses, and solid waste management were addressed separately. Their interactions with each other and the environment were often overlooked or underestimated. Several factors are common to most of the cities, such as ageing drainage systems and increased population density due to new developments in core city areas. Thus, the interactions for any particular city will depend in detail on the geographical location of the city and the local climate and weather conditions.

i) Integrated planning and co-ordination will be ensured to take into account all components of the urban water systems, and

ii) BMPs should be adopted by all ULBs to reduce the load on the major drainage system.

[Action: States/UTs and ULBs]

4.22 Specific Adaptation Strategies for Cities

4.22.1 For planning DM strategies, factors such as projected population, available land/ space, developmental potential and land use should be considered. These should take into account the topography, specific features and the city scenarios, namely, coastal, on banks of river, downstream/ upstream of dam, inland city, hilly cities, etc. A city may be a combination of these, for example Mumbai is both a coastal city and on the banks of the River Mithi flowing through it. Surat is a city located on a river bank and also located downstream of Tapi dam.

4.22.2 Coastal Cities

4.22.2.1 Drainage in cities located near or on the coast is affected by the tidal variations in the outfalls discharging to the sea and possible rise in the sea water levels. Very often, outfalls are not equipped with flood gates and, as a result, there is no way to prevent sea-water from entering into the drainage system during high tide. For instance, in Mumbai, only 3 out of 105 outfalls are equipped with flood gates.

4.22.3 Cities on River Banks

4.22.3.1 Cities located on the banks of rivers are susceptible to flooding from the flows in the river due to rainfall occurring directly over the catchment or in the upstream reaches of the river which may be a considerable distance away from the city. The upper catchment may sometimes lie in another state as well. Many of the incidences could have been better handled if there was a SOP based on real-time inputs and better coordination. The situation could be aggravated with heavy localised rainfall.

4.22.4 Cities Near Dams / Reservoirs

4.22.4.1 For cities located either downstream or upstream of dams, the measures to be taken are similar to the cities located on rivers. In addition, there should be timely operation of the dam gates by the irrigation department, based on the real-time inputs from rainfall and flow gauges in coordination with the local bodies of the affected cities.

4.22.5 Inland City

4.22.5.1 Some cities may be totally landlocked and flooding is a result of urbanization in the saucer-shaped catchment. In many cases, the effects of flooding can be minimized by careful positioning of buildings in relation to the topography and suitable design of landscaping features.

4.22.6 Cities in Hilly Areas

4.22.6.1 Surface erosion, landslides and flooding are linked phenomena for a city located in hilly areas and the flow velocities are high due to the steep slopes. Therefore, integrated land-use planning should be taken up in hilly areas for mitigating flooding. Management measures should include Ecological Management Practices (EMPs) for controlling sediment and water yield from the upper catchments, design of adequate drainage system with contour drains (catch water drain), improvement of subsurface drainage, sediment trap of different forms, adequate culvert and drop structures.

4.22.6.2 For cities expanding towards a valley from the core of the urban centre located at ridge, buildings should be made on stilts as conventionally practised. For the cities expanding into the hills from the core of urban centre located on plains, houses should

preferably be built on stilts with approach road moving uphill. If such approach is difficult due to economic and other practical constraints, houses should be constructed with minimum disturbance to the natural terrain and natural cover, with implementation of optimal EMPs.

i) Low-lying areas should be reserved for parks and other low-impact human activities,

ii) Wherever unavoidable, buildings in low-lying areas should be constructed on stilts above the High Flood Level (HFL)/ Full Tank Level (FTL),

iii) For chronic flooding spots, alternate locations may be explored for accommodating people staying there,

iv) Buildings should be constructed on stilts after taking into account the stability of slopes, and

v) Stormwater drainage systems for coastal cities have to be designed taking into account the tidal variations.

[Action: MoUD, States/UTs and ULBs]

4.23 Encroachments

4.23.1 Natural streams and watercourses have formed over thousands of years due to the forces of flowing water in the respective watersheds. Habitations started growing into towns and cities alongside rivers and watercourses. As a result of this, the flow of water has increased in proportion to the urbanization of the watersheds. Ideally, the natural drains should have been widened (similar to road widening for increased traffic) to accommodate the higher flows of stormwater. But on the contrary, there have been large scale encroachments on the natural drains and the river flood plains. Consequently the capacity of the natural drains has decreased, resulting in flooding.

i) Encroachments on nallahs/ drains/ watercourses will be removed by providing alternative accommodation to the Below Poverty Line (BPL) people and appropriarte rehabilitation package for other categories of people,

ii) The nallahs/ drains/ watercourses/ flood plains should be clearly delineated and boundaries fixed in new developments. There will be strict enforcement of the relevant byelaws/regulations in the new layouts as discussed in Chapter 6, and

iii) Any encroachment on the drain will attract penal action and be treated as a cognizable offence, both against the encroachers and the officials responsible for enforcement of the byelaws/ regulations.

[Action: MoUD, States/UTs and ULBs]

5 Urban Flood Disaster Risk Management

Yokohama Strategy

The Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation and its Plan of Action adopted in 1994 provides landmark guidance on reducing disaster risk and the impacts of disasters.

The review of progress made in implementing the Yokohama Strategy identifies major challenges for the coming years in ensuring more systematic action to address disaster risks in the context of sustainable development and in building resilience through enhanced national and local capabilities to manage and reduce risk.

5.1 Overview

5.1.1 Sustainable management of urban flood risk is becoming increasingly challenging for urban communities as well as ULBs, which are responsible to address this. As already discussed, it was only after the Mumbai floods of July 2005 that the nation realised the possibility of unprecedented rainfall intensities occurring over urban areas and the potential of the enormity of devastation that can be caused by such events. Subsequently, it has been observed that urban flooding has been happening in different cities and many of them are not able to cope with these challenges in a holistic manner.

5.1.2 The reasons for this are manifold. This requires a paradigm shift in the approach to DM, which proceeds from the conviction that development cannot be sustainable unless disaster mitigation is integrated into the planning and development process. It has been universally accepted that returns on investments on mitigation are very high. It is usually said in the context of disaster risk reduction that one pays something for doing and pays much more for not doing. Developing appropriate coping strategies and disaster risk reduction plans, along with greater awareness of how to reduce risks, is the high priority agenda for DM in India. This will be based on:

i. Enhancing national, state and local scale advocacy partnerships and knowledge management for mainstreaming disaster risk reduction,

ii. Standardizing hazard risk management tools, methodologies and practices,

iii. Developing integrated and coordinated approaches backed by prudent SOPs at all levels of UFDM,

iv. Incorporating 'Learning by Doing' mode of operations and also through exchanging experiences/best practices,

v. Promoting the diffusion/documentation of best practices in UFDM,

vi. Initiating appropriate R&D projects as per the emerging needs on regular basis,

vii. Building appropriate communication protocols facilitating multi-platform and multi-lingual dissemination,

viii. Analysing and presenting the information in an easily understandable form, for wider use by decision-makers,

ix. Encouraging integrated approaches of project implementation based on Master Plan, and

x. Encouraging states/ ULBs to accord top priority to deal with recurring urban flooding cases by leveraging more funds.

5.2 Issues in Urban Flood Disaster Risk Management

Following are some of the shortcomings in management of Urban Flooding:

i) Comprehensive risk assessment,
ii) Factoring risks in development planning,
iii) Coordination among different institutions,
iv) Lack of information sharing,
v) Disintegrated investment decisions, and
vi) Lack of consultation with stakeholders.

5.2.1 Risk management process is a comprehensive understanding, analysis and assessment of urban flood risks, before flood mitigation measures are planned and implemented. It is the only way to provide city planners with information about the component of risk that is prevailing in the area under consideration. Vulnerability should be considered in a broad context, encompassing specific physical location of the area and human, socio-economic and environmental dimensions that relate to social inequalities based on age, gender, ethnicity and economic divisions. Disaster risk reduction strategies include enhancing preparedness, response and recovery. This can be achieved by improving institutional capacities and operational abilities based on local scale vulnerability analysis and risk assessment. Further, assessing the vulnerability of lifeline infrastructure is crucial to the sustainability of social and economic sectors.

5.2.2 Factors contributing to urban flooding, the different city scenarios, impact of climate change on sea-level rise, weather systems experienced in India, urbanisation trends and pressure on land, factors like urban heat island effects and increasing rainfall in urban areas, temporal and spatial variation of rainfall and several other issues have already been discussed in Chapter 1. Issues relating to early warning and communication, design and management of SWD systems have also been discussed in the respective chapters.

5.2.3 Sharing information and experience for the purpose of public awareness and imparting

professional training of disaster managers in all forms of education is essential for creating a culture of safety and capacity development. Infusion of proven scientific knowledge with the state-of-the-art spatial, security, ICT and location technologies are central to the local scale disaster risk management by interfacing micro-level details such as topographic, thematic, demographic and socio-economic information.

Decisions for new development (properties and infrastructure) are often taken without a full understanding of the risks of flooding. Consideration of new developments on a case-by-case basis, can ignore cumulative stormwater effects on flood risks. As organisations manage different parts of the urban drainage infrastructure, they make investment decisions based on a limited cost-benefit analysis that rarely considers the wider drainage issues. The sum total of these individual and piecemeal investment strategies is unlikely to produce the most effective solution. MoUD will ensure that this is appropriately reviewed on a regular basis.

[Action: MoUD and States/UTs]

5.2.4 Contrasting Urban Flood Management Approaches

Table 5.1: Details of Contrasting Approaches to the Management of Urban Floods

Rescue and Relief Centric Approach		Holistic DM Approach
1. Primary focus on hazards and disaster events	Emphasis	1. Primary focus on vulnerability and risk issues
2. Single, event-based scenarios		2. Dynamic, multiple risk issues and development of possible scenarios
3. Basic responsibility to respond to an event		3. Fundamental need to assess, monitor and continuously update exposure to changing conditions
4. Often fixed, location-specific conditions	Operations	4. Extended, changing, shared or regional, local variations
5. Command and control, directed operations		5. Situation-specific functions
6. Established hierarchical relationships		6. Shifting, fluid and tangential relationships
7. Often focused on hardware and equipment		7. Dependent on related practices, abilities, and knowledge base
8. Dependent on specialized expertise		8. Specialized expertise, squared with public views and priorities

9. Urgent, immediate and short time frames in outlook, planning, attention, returns	Time Horizons	9. In addition to short term measures, moderate and long time frames in outlook, planning and returns
10. Rapidly changing, dynamic information usage, often conflicting or sensitive 11. Primary, authorized or singular information sources, need for definitive facts 12. Directed, "need to know" basis of information dissemination, availability 13. Operational/ public information based on use of communications	Information use and Management	10. Accumulated, historical, layered, updated, or comparative use of information 11. Open or public information, multiple, diverse or changing sources, differing perspectives, points of view. 12. Multiple use, shared exchange, inter-sectoral use of information 13. Nodal communication

5.3 Watershed as Basis for Management of Urban Flooding

5.3.1 A ULB consists of a number of municipal wards which are usually the administrative units. Planning on a ward-wise basis is usually done for most of the activities because of administrative convenience and also as it is a constituency for the elected member of the ULB. It is a different matter that the jurisdiction of a municipal ward can change with time due to delimitation of constituencies from time to time.

5.3.2 As already discussed, urban areas comprise of natural watersheds, which, in turn, are made up of smaller catchments. The entire watershed, however, drains into a single water body like lake or river. While catchment will be the basis for the purpose of designing stormwater drainage system, any planning for effective urban flood management has to take into the consideration the entire watershed. Accordingly, responsibilities for management of the stormwater drainage system should be shared at all times on the basis of a watershed. This will facilitate effective UFDM actions.

5.3.4 With enhanced real-time observational network backed by improved early warning capabilities including the installation of DWRs, watershed based warnings can be communicated to the public, which will be more meaningful, and the ULB administration can be geared up to be better prepared to respond and also to deal with future flooding events.

Following actions for Urban Flooding Management will be taken on Watershed Basis:

i. Preparedness and mitigation,

ii. Early warning and communication,

iii. Response,

iv. Awareness generation, and

v. Community capacity development.

5.4 Vulnerability Analysis and Risk Assessment

5.4.1 Presently, there are no flood risk assessments for many of the cities/towns for planning the DRM. An urban flood risk management plan has to start with the assessment of present and future flood risks. The clear understanding and distinction between the three components that define the degree of risk i.e., hazard, vulnerability and ability to cope with, provides the necessary information for the overall management of risks. Risk assessment has to be carried out in an integrated manner, i.e. identifying all the possible hazards, including consequence of urbanization or other development activities in future.

5.4.2 The hydrologic and hydraulic characteristics of these hazards have to be inventoried in addition to the economic, political, socio-cultural and ecological environment information of the flood prone/ vulnerable areas. Such an assessment should give information about the probability of a hazard's occurrence and the respective potential damage and loss.

5.4.3 A number of different scenarios should be modelled, in order to understand the consequences of likely future urban floods (future urbanization, climate change and land use changes, etc.). The results of such models provide information about the expected flood frequencies and magnitudes (extent, depth, duration and flow velocities), thereby mapping of areas and elements, which are exposed to floods.

5.4.4 Risk, Hazard Assessment and Mapping

5.4.4.1 Flood management professionals should evaluate the levels of acceptable risk, based on specific site conditions, to make people aware what risk is present in their lives, and to assist them in making formal acceptance, based on which adequate flood protection measures can be taken up.

5.4.4.2 Flood hazard means the threat to life or the threat of damage to property as a consequence of flooding. Hazard maps have to be presented in a form that is fully understandable, with all affected populated areas, facilities and structures indicated and marked. Hazard zoning maps present hazard levels together with the probable intensity of magnitude in each hazard zone.

5.4.4.3 Risk is a quantification of hazard. Risk mapping is the activity where elements at risk are plotted on hazard maps. Risk maps may include certain guidance, advice and indication of escape routes, safe access ways, etc. Risk assessment that provides the planner with an estimate of the expected material losses includes:

i) Identification of areas at risk upon its exposure to hazard,

ii) Classification of structures according to function,

iv) Estimation of risk for each structure type, and

v) Estimation of all risks for each function and then for each area.

5.4.4.4 There are also economically non-quantifiable aspects, such as potential loss of life and indirect secondary losses. For their evaluation and assessment, standard indicators for housing areas, infrastructure and various economic activities are eventually made available by state authorities that regulate insurance policies.

5.4.4.5 A flood risk map has several direct economic effects, since it causes revision of all planning maps for the area. On the negative side, it may lower property value in the flood-prone areas and may stop development. On the positive side, the map initiates the construction of flood loss prevention structures, alerts prospective land and property owners, as well as provides new developing ideas to the local planning authorities.

i) Risk assessment will be carried out with a multi-hazard concept leading to foolproof land use planning,

ii) Quantification of risks will start with the analysis of hydro-meteorological data and the hydraulic simulation of floods, and

iii) Flood hazard assessment will be made for standard baseline conditions to ascertain level of acceptable risk of flooding, on the basis of projected future scenarios of rainfall intensities and duration and land use changes.

[Action: CWC, SoI, NRSC and SRSACs]

5.5 Estimation of Possible Inundation levels

5.5.1 The natural drainage system within an urban area is highly modified and its hydraulic characteristics are affected by day-to-day activities like dumping of solid waste into the drainage system. The characteristics of surface runoffs also tend to overwhelm and impact the carrying capacity of surface drainage system. As such, determination of the likely flood prone areas due to localised flooding is complicated and has to be undertaken with greater understanding of all the factors affecting the drainage systems.

5.5.2 Cities/ towns close to the coast-lines are susceptible to flooding due to storm surges during cyclonic/ tsunami events and compounded with intense rainfall associated with cyclones/ depressions. Further, projected climate change induced sea-level rise will also be taken into consideration for arriving at possible inundation. Similarly cities/ town adjacent to river systems need to be simulated for maximum possible inundation, occurring for different inflows and discharges. Cities/ towns on the upstream side of reservoirs shall be analyzed for maximum possible inundation due to backwater effect. Similarly, the effect of sudden release of water from reservoirs/ dams on the cities/towns located on the downstream side also need to be analysed.

5.5.3 Probable maximum inundation due to intense localised rainfall causing flash floods shall be simulated for various intensities of rainfall as the recent times have shown high intensity rainfall over urban areas in shorter intervals than the recorded historical events. Similarly, the coastal cities shall be analyzed/ simulated for possible inundation due to maximum probable storm surge and the inundation levels for various intensities of cyclones taking high tide into consideration. The maximum probable inundation in the cities/ towns adjacent to river systems and falling within the flood plains shall be arrived at by simulating the flows in the river systems for various intensity of flows and return periods. While mapping the inundation prone areas existing drainage capacities of the cities need to be considered for arriving at the duration of such flash flood situation.

The magnitudes of inundation levels due to various scenarios and causes will be simulated on GIS-based inundation model, duly incorporating drainage capacities in the analysis in order to estimate depth, duration and extent of inundation by using an integrated city specific framework.

[Action: CWC, NRSC and SRSACs]

5.6 Estimation of Flood Damages

Losses due to urban flooding

Direct losses: Losses resulting from direct contact with flood water, to buildings and infrastructure, human and animal lives.

Indirect losses: Losses resulting from the event but not from its direct impact, for example, transport disruption, business losses that can't be made up, losses of family income, etc.

In both loss categories, there are two clear sub-categories of loss:

Tangible losses: Loss of things that have a monetary (replacement) value, for example, buildings, infrastructure, etc.

Intangible losses: Loss of things that cannot be bought and sold, for example, lives and injuries, heritage items, memorabilia, etc.

5.6.1 The impact of urban floods can be:

- Physical,
- Economic, and
- Environmental

The magnitude of the damage of an urban flood depends on the flood depth, flow velocity, water quality, duration and sediment load. Constant updating of demographic data, infrastructure details, communication network details and the details related to property, economic activity of the individuals in the flood prone areas will enable the realistic estimation of damages/ probable damages and preparation of spatial database for the urban area which would help in instantaneous assessment of damages as well as for flood disaster risk management master planning.

5.6.2 The primary benefit derived from flood management, expressed in economic terms, are those arising from the reduction of flood damage. Cost saving due to reduction of flood damage must be compared with the cost of implementing flood management measures, making flood damage estimate the most important component of a flood appraisal process.

In general, the assessment of potential damages will be on the following basis (Actual damages will be on the basis of a field survey):

i) Identification of potential damage areas, according to the physical characteristics of the area such as land use, topography, drainage area, outfall system and the capacity of the existing stormwater drainage system. Maps are usually prepared to visualise the results of the identification process,

ii) Selection of damage categories, which are considered appropriate for each damage area under investigation. These are: public and private clean-up, structural and vehicular damage, damage of contents, traffic related losses and tax revenue losses,

iii) Developing unit-cost relationships for various damage categories,

iv) Evaluation of hydraulic conditions such as the volume of ponding areas, street conveyance capacities, storm sewer capacities and inlet capacities,

v) Determination of the extent of flooding expected for several storms of different frequencies of occurrence,

vi) Estimating damages for the "do-nothing" alternative for different storm frequencies,

vii) Plotting corresponding damages versus probability, in order to measure the area under the curve which represents the average annual damage (base-line damage),

viii) Estimating residual damages in a similar manner, for various alternative plans under study,

ix) Calculating annual benefit as the difference between the estimated annual damage, before and after the capital improvement, and

x) The estimated annual benefit may then be used in the cost-benefit analysis.

[Action: CWC, IMD, SoI, NRSC and SRSACs]

5.7 Ward level Risk Reduction and Vulnerability Assessment

5.7.1 While watershed shall be the basis for planning for stormwater drainage systems for each urban area, ward level risk reduction and assessment of vulnerability is to be carried out through community based strategy and institutionalizing ingestion of traditional/local wisdom into risk analysis. The information thus generated will be useful in preparation of long-term disaster risk reduction action plans and optimum land use plans with community participation at community level.

Ward level information system will have to be developed using high resolution satellite images/ aerial photos integrated with socio-economic data covering natural resources and infrastructure facilities on appropriate scale (1:1000) at community level.

[Action: SoI, NRSC, States/ UTs, SRSACs and ULBs]

5.7.2 Hazard Risk Zoning and Mapping

5.7.2.1 The foregoing efforts will enable the development of micro-scale hazard vulnerability and risk zoning maps and classification of all information on priority. This will provide a basis for development of appropriate mitigation options and effective utilization of funds for holistic risk reduction.

Elements of Vulnerability Reduction

The key elements of Long Term Vulnerability Reduction Plan are:

A. Disaster Risk Identification (Hazard and Vulnerability Assessment),

B. Disaster Risk Reduction (Mitigation and Regulation), and

C. Disaster Risk Transfer (Relief and Insurance).

Additional elements include:

i. Capacity analysis of zone/ward/community level stakeholders in government and community to manage disasters,

ii. Evolving well-defined disaster mitigation measures (structural/non-structural) in all pre- and post-disaster actions. The emphasis in disaster mitigation is on critical aspects such as safe location, safe design and safe construction of

new structures, infrastructure and settlements. Based on the hazard-risk-vulnerability assessment, standard mitigation measures will be readily identified and adopted for existing key infrastructure,

iii. Identification of appropriate regulatory actions required for ensuring compliance with regard to disaster mitigation by considering the vulnerability levels and the existing regulations in place,

iv. Review of existing land-use and building regulations procedures/ practices to identify appropriate disaster mitigation measures,

v. Mechanism for disaster risk transfer through community-based informal micro-finance/ micro-credit and micro-insurance arrangements,

vi. Incentive mechanism for siting/relocating infrastructure to safe locations,

vii. Cost-benefit analysis of urban flood disaster impacts and mitigation options,

viii. Updating the existing SOPs in the urban flood contingency plan of the ULBs and review of relief codes, and

ix. Institutionalizing clearly defined roles and responsibilities of all key agencies (government/non-government).

5.8 Reducing Vulnerability

5.8.1 Vulnerabilities are generally due to the geographical features of an area, meteorological phenomenon, unsafe conditions that are developed by human actions or inactions. So, it is essential to identify the root causes of these vulnerabilities, specific to an area under consideration in order to mitigate the causes rather than the consequences.

5.8.2 Reducing Physical Vulnerability of People and Infrastructure

5.8.2.1 Physical vulnerability of an area is mainly due to the natural features of that area which are difficult to alter or completely change to make the area safe against urban flood risk. However, the physical vulnerability of an area can be mitigated by ensuring adequate access to basic needs like flood shelters, medical facilities, etc. and by improving the preparedness, comprising of updated evacuation plans, frequently updated building codes and a list of retrofitting plans suitable for an area.

5.8.3 Reducing Socio-economic Vulnerability

5.8.3.1 Socio-economic vulnerability of an area is mainly related to the economical conditions and social fabric of the population living in the area under consideration. Reducing the socio-economic vulnerability is on a long-term perspective. In arriving at the measures required for the area to make it less vulnerable due to urban floods, policy decisions related to the area need to be taken involving political leadership of the area, institutionalizing participatory approaches and supporting community-based organizations (CBOs). It will also cover economic development plans duly diversifying the income sources and implementing flood insurance schemes.

5.8.4 Insurance and Risk Transfer

5.8.4.1 Over the past decade, urban India has experienced series of floods, resulting in damages worth hundreds of crores of rupees. Government provides very nominal

compensation to people BPL, while a large number of middle and high income people do not receive any compensation.

5.8.4.2 Insurance is a major tool for risk transfer, which covers high risks with minimum premiums. Micro-insurance and micro-credit are the services developed especially for low-income groups.

i) Research on how floods threaten vulnerable urban populations and how they are affected must be developed in order to develop the best strategies for disaster mitigation. The research should be set in the Indian techno-legal context and draw from the Indian experience. The research should focus on three key areas: risk identification, risk pooling and risk transfer. The risk should focus on both property, people, and

ii) States/UTs will build partnerships with public/ private insurance companies and civil society to sensitise communities about available schemes and also develop appropriate micro-insurance schemes, targeted at low-income groups. The partnerships should be based upon need, post performance, key objectives and cost effectiveness. A database of partners should be available in the public domain.

[Action: States/UTs and ULBs]

5.9 Spatial Decision Support Systems for Urban Flood Management

5.9.1 Development of objective for effective disaster risk management framework involves implementation of application software with all defined linkages with natural disaster specific data and information management. Main components of real-time DSSs to evolve emergency response, relief routing, rehabilitation planning during the disaster are fail-safe and seamless communication infrastructure, data distribution and data management systems. This is necessary for DRM through local scale vulnerabilities, risk mapping and mitigation planning for sustainable development including sustenance of land and water resources. Communication systems will provide real-time data and information to support control centres and operating agencies related to disaster monitoring, mitigation and enforcement. Sub-components of risk management support systems are:

i. Data Distribution Centre (DDC),

ii. Data Validation Centre (DVC),

iii. Data Processing and Application Development (DPAD), and

iv. DSS to cater to the requirement of pre-, during, post-disaster activities, scenario development, mitigation planning, etc.

5.10 National Database for Mapping Attributes

5.10.1 Developing the DSS requires considerable application of software development and GIS specific activity, which calls for adequate number of specific systems and tools. Implementation of DSS is sustainable only when backed up with the national level high-end infrastructure comprising:

i. High-end computing,

ii. Storage and communication network,

iii. 3-D Virtual reality visual studio,

iv. Centralized comprehensive data bank for urban flood risk management with nodes in various states/ UTs over a fail-safe communication backbone with NDMA, SDMAs / DDMAs and ULBs, and

v. State-of-the-Art Command/ Control Operations Center for effective coordination of disaster response actions.

5.10.2 High-end computing, visualization, networking and communication command control infrastructure will essentially carry out information and data fusion involving collating, analyzing, interpreting, translation of monitoring and early warning from line departments, based on state-of-the-art and S&T know-how. The developed impact assessment and emergency response management system under DSS is used for generating early warning based impact assessment scenarios for response planning; mitigation and risk reduction based developmental planning. The DSS can essentially assist to organise and/or mobilize necessary response resources by the states/UTs, and ULBs simultaneously with the public actually reacting to warnings for effective emergency response management. Development of such a system becomes particularly useful when the public's reaction to a warning translates immediately into increased demand on public services.

5.10.3 Further, it is necessary to include cost-benefit analysis for all States/UTs as part of DSS that would allow the losses and costs to be normalized for changes in population, wealth and inflation in the affected areas. To maximize the usefulness of such cost-benefit analysis, the database of DSS will include the expenses associated with urban flood warning and information services and mitigation efforts, as well as including vulnerability and societal impacts of urban floods.

i) The database required for mapping different ward/community level attributes will be made accessible to all ULBs and concerned departments/ agencies/ stakeholders,

ii) Integration between hardware and software will be ensured for compatibility and interoperability of computing, visual and networking infrastructure nodes at the centre and state/ ULB/ward levels, and

iii) Coastal ULBs/ Urban Development Authorities will work out micro-level analytical tools with appropriate interfaces to DSSs for planning and executing suitable risk reduction activities.

[Action: MoUD, States/UTs and ULBs]

5.11 National Urban Information System

5.11.1 As already discussed in Chapter 2, NUIS scheme was launched for creating urban information system to meet the requirements of urban planning. 158 cities and towns from Class-I to Class-VI from each state and UTs are being covered in phases. Under this scheme, both attribute and thematic spatial data at various levels are being generated for urban planning and decision support. Twelve

thematic spatial data layers viz urban land use/cover, physiography (outside city area), geomorphology (outside city area), geological structure (outside city area), lithology (outside city area), drainage, soil cover, texture and depth (outside city area), surface water bodies, road, rail, canal and transportation routes are being covered in the database.

5.11.2 The database creation uses modern data sets such as satellite images and aerial photographs to generate comprehensive spatial data in 3 scales i.e. 1:10,000 for Zonal Development Plan/ Master Plan/Development Plan, 1:2000 for detailed Development Plan and 1:1000 for utility planning for sewerage and drainage.

i) All Class I, II and III Towns, with population of 20,000 or more (on the basis of 2001 Census), will be mapped on the GIS platform under the NUIS,

ii) The database of the NUIS will be expanded to cover infrastructure facilities at community level integrated with socio-economic data, and

iii) Maps will be generated at 0.2 - 0.5 m contour intervals.

[Actions : MoUD and SoI]

5.12 State Urban Flood Disaster Management Information System

5.12.1 Establishment of a comprehensive Urban Flood Disaster Management Information System (UFDMIS) covering all phases of DM is highly essential to provide online services to the ULBs and other departments related to DM in the State. Initially a review has to be carried out on availability of digital data, existing infrastructure and requirements for creating database for cities/towns throughout the State/UTs. Development of such a comprehensive management information system has to be on the basis of detailed studies, encompassing a wide variety of spatial and non-spatial data. This will assist the DM cells for planning and monitoring the progress of mitigation works. Various components of UFDMIS are listed below:

i. Hazard, risk and vulnerability (with ward level/ watershed level hazard maps of flood inundation, storm surge inundation along with the quantification of vulnerability and associated risk and identification of vulnerable groups),

ii. Urban flood early warnings and lead time spatial hazard maps,

iii. Inventory of infrastructure in vulnerable areas developed by engineering department of ULBs and monitoring of maintenance of existing infrastructure and new mitigation works, for long term risk reduction,

iv. Damage assessment in a post-disaster scenario, including standardization of post-event survey formats,

v. Hazard DSS for emergency response, relief routing and rehabilitation/ evacuation planning,

vi. Support for sensitization and awareness raising including simulation exercises and mock drills,

vii. Appropriate visual support tools for all phases of disaster cycle viz. preparedness; prevention; mitigation; relief; rescue; rehabilitation and recovery,

viii. Desktop interface for DM administration for exploring, probing and updation of core and disaster specific data sets with common format of inventory,

ix. Support for management and maintenance of lifeline infrastructure (flood shelters, hospitals, schools, places of worship, etc.),

x. Management support for monitoring maintenance and execution of critical mitigation projects,

xi. Directory of DM authorities at all levels – resources and contact details of all stakeholders (Government, NGOs, elected representatives of Parliament, Legislature, ULBs, RWAs, Hospitals, etc.), and

xii. Documentation support for a) all past urban flood events; b) reports prepared and compiled by independent groups and agencies; c) planning future programme, and d) R&D initiatives for improving urban flood risk management capabilities.

The Technical Umbrella at the state level will ensure the establishment of a comprehensive UFDMIS.
[Action: States/ UTs]

5.13 Data Providers for Disaster Risk Management

5.13.1 The dynamic nature of an emergency situation calls for timely updating of a variety of required data/information from various organizations, as no individual agency can produce and update all the required information. This calls for partnership with a mindset for data sharing and data exchanging. Main data types that are to be acquired for DM from:

Static Data Providers

i) Topographical maps and hydrological maps on different scales - Survey of India (SoI), Central Ground Water Board (CGWB)/ CWC,

ii) River catchment area and basin maps pertaining to the ULB-CWC,

iii) Catchment area maps for all streams that pass through/ passing by the side of the ULBs - Irrigation Department, and

iv) Details about tanks/ water bodies along with their capacity, FTLs, inlet and outlet arrangement - Irrigation Department.

Dynamic Data Providers

i. Real-time rainfall data from ULBs/ Hydro-meteorological data - IMD/ CWC,

ii. Census maps and census data - Census Department,

iii. Maps and atlases for the cities - National Thematic Mapping Organisation (NATMO),

iv. National and city level coverage of satellite images of all resolutions including ALTM - NRSC,

v. Coverage of soil maps on all scales - National Bureau of Soil Survey and Land-use Planning (NBSSLUP),

vi. City level coverage of forest maps on all scales - Forest Survey of India (FSI),

vii. City level coverage of land use maps, ground water potential maps and other thematic maps on all scales - NRSC,

viii. Naval Hydrographic Charts - NHO,

ix. Data from state government line departments - Irrigation, Health, Municipal Authorities, Roads and Buildings, Police, Fire Services, Civil Supplies, Transport, Electricity, etc.,

x. Data about railway lines passing through/ near urban areas, telecommunication network of various service providers operating in the area - Railway and State Government,

xi. Urban transport network data from the local transport corporation - Transport Department, and

xii. Data pertaining to coastal and marine areas management, specifically for urban areas - MoES.

5.13.2 The above data sources list is only illustrative and not an exhaustive list of known agencies, providing data of relevance to DM. Data may be available in various forms in many other departments/organizations/ industry/ NGOs. Data resources of various agencies have to be studied in detail and a mechanism will be evolved for ensuring that this data, whenever relevant, becomes authentic part of the national data for DRM.

5.13.3 To achieve this aim, the required information for DM will be recognized and a UFDMIS framework established. The responsibility of maintaining the information will be shared between different organizations based on:

i) Appropriate and accepted policies,

ii) Appropriate standards for the production of data,

iii) The training of people to work with these datasets,

iv) The establishment of appropriate network and software tools for exchanging and sharing information/ data, and

v) Appropriate policies for accessing and using data/information.

a) Standards and interoperability protocols will be implemented by stakeholders,

b) Logically all the producing and updating agencies manage their sectoral datasets during their everyday business and emergency situations. If the results of such data production and updating efforts are physically recorded, the required data/information for disaster response is always available to the producer. If this information is shared and exchanged, datasets will be accessible to a wider emergency management community, and

c) A committee set up by NDMA will be empowered to review the data needs and make data sets available to all stakeholders for holistic DM.

[Action: NDMA, SDMAs and ULBs]

5.13.4 Specific core data requirements and the ongoing efforts in this regard are summarized in Table 5.2.

5.14 Updating of Database through Additional Surveys

5.14.1 The detailed analysis of inventory of spatial database and relevant attribute information, residing with various departments will enable the formulation of strategies and guidelines for generation/updating the database and subsequent organization of database. It will facilitate:

Table 5.2: Current Efforts for Core Spatial Data Generation in the Country

Agency Responsible with Augmentation of Resources	Scales of Spatial Data
Survey of India • MoEF is funding Vulnerability Line Mapping pilot project. Project completion to be expedited and to be scaled up for the entire coastline • XI Plan Working Group Recommended for funding 1:10000/1:8000 scale digital topographic fields for all multi-hazard zones (coastal areas to be taken up on priority) • 1:25000 scale coastal topographic maps are generated under Department of Ocean Development Funded Project. Digitization work to be funded on priority • 1:50000 scale data digitization is near completion under NSDI Programme Initiative • High Altitude Airstrip project will provide the capability, for not only establishing communication network, but also carry out continuous imaging with different sensors of the affected areas, with large footprint of 500 km diameter, need to funded on priority in XI Plan	• 1:2000/1:4000 scale in metro cities/ urban areas in coastal areas [Coastal seaward stretch of Vulnerability Line/Setback Zone] • 1:8000/1:10000 [Coastal seaward stretch falling beyond Vulnerability Line and up to 10km inland] • 1:25000 [Coastal seaward stretch falling beyond 10km inland and up to 20km inland to cover complete delta areas] • 1:50000 [Coastal district areas beyond 20km inland]
NDEM Initiative of Department of Space (partly funded by MHA) • 1:50000 scale digital topographic, thematic, infrastructure and natural resources fields are completed for about 60 multi-hazard districts • 1:10000/1:2000 scale efforts are slated for XI Plan. Efforts on priority basis for coastal belt need to be funded • Procurement of ALTM infrastructure with aircrafts, sensors and instrumentation/ communication needs funding support in XI Plan	• Digitization of thematic, infrastructure and natural resources are to be taken up for all districts, vulnerable to cyclones on priority basis at 1:50000 scale • 1:10000 scale digital topographic, thematic and many other fields for urban areas of more than 1-lakh population and all river basins • 1:2000 scale digital topographic, thematic and many other fields for mega cities
Efforts will be made for generating specific core data on priority. Action: DST/SoI, DoS/NRSC and SRSACs]	

i. Identification of spatial datasets and attributes, required to be generated and/or refined,

ii. Development of semi-automated or automated tools for data conversion and organizing them as per NSDI and NDEM spatial frameworks,

iii. Development of automated tools for database validation, adhering to the NSDI and NDEM database standards,

iv. Design of standard look-up table templates, in order to avoid inconsistencies across various departments, and

v. Generation of predefined symbols for various spatial datasets.

5.14.2 Vulnerable Housing, Power and Communication Network Towers

i. Details of habitation scale thatched houses, tiled-roof houses, sheet-roofed houses, etc.,

ii. Details of population living in vulnerable house types, and

iii. Details of ward-level length of different categories of power and communications lines and towers, along with their design standards and structural details.

Spatial databases will be standardized with provision for frequent updates and automated procedures/ tools for organising the collected data as per NSDI and NDEM spatial frameworks.

[Action: SoI and NRSC]

5.15 Development Planning for Disaster Reduction

5.15.1 The contemporary approach assumes that DM must be shared by all sectors and activities that have any connection with development and change at all levels of policy making. In this approach, vulnerability is reduced by integrating measures for survival, rehabilitation and reconstruction within development planning.

5.15.2 Prerequisites for development planning for disaster reduction are as follows:

i) acceptance that disasters can happen,

ii) perceptions of causes, incidences and effects of environmental hazards,

iii) integration of perceptions in a development policy, meaning preparation of development guidelines for disaster reduction, and

iv) evaluation of all development proposals and plans against development guidelines.

5.16 Flood Management Master Planning Process

5.16.1 The flood management master planning process is a systems approach that includes:

i) Setting up preliminary goals and objectives for a foreseeable future, consistent with laws in force and other constraints,

ii) Documentation of the problem; investigation of the causes of the problems; determination of needs and the planning criteria,

iii) Problem inventory; appraisal of feasible solutions; setting up flooding standards based on social, economic and environmental factors,

iv) Collection of all baseline data and identification of baseline conditions, including political, geographic, hydrologic and environmental issues,

v) Systematic interviews and site visits,

vi) Description of the existing stormwater practice and its inadequacies,

vii) Definition of hydrologic conditions and constraints that proposed changes or development would have on baseline conditions,

viii) Definition of interdependencies with neighbouring administrative areas and related municipal infrastructure services,

ix) Analytical work that includes hydrologic, hydraulic and water quality analysis,

x) Definition of priorities and alternative solutions (interim solutions, long-range solutions),

xi) Description and cost estimate of proposed facilities and measures,

xii) Benefit/ cost analysis and comparative evaluation of alternative solutions, including valuation of benefits, damage assessment, cost of traffic disruption, environmental and social factors; other assessment techniques that are more appropriate for urban conditions,

xiii) Recognition of alternative plans; recognition of emergency plans,

xiv) Practical financing program; identification of the sources of funds, and

xv) Drafting legal documents needed to implement the adopted measures.

5.17 Urban Flooding Cells

National Level

It is for the first time that urban flooding is being dealt with as a separate disaster, de-linking it from riverine floods which affect the rural areas. MoUD is being designated as the Nodal Ministry for urban flooding.

i) A separate Urban Flooding Cell (UFC) will be constituted within MoUD,

ii) A Joint Secretary cadre officer will be designated as the Nodal Officer in charge,

iii) It will play a lead role in the establishment of the Technical Umbrella at the national level,

iv) It will coordinate all UFDM efforts by different stakeholders at the national level,

v) It will guide the states on all aspects of UFDM, and

vi) It will guide efforts for the preparation of the Stormwater Drainage Manual and set up a standing mechanism for updating it as per international practice.
[Action: MoUD]

In States/UTs

The Department of Municipal Administration/ Urban Development in the State/UT will be the nodal department for the management of urban flooding.

i) A separate Urban Flooding Cell will be constituted within nodal department,

ii) A Joint Secretary cadre officer will be designated as the Nodal Officer in charge,

iii) It will take the lead to establish a state level monitoring and approval mechanism for UFDM particularly as a part of the Technical Umbrella, and

iv) It will guide all the ULBs in all aspects of UFDM. UFC shall be formed with members from Irrigation Department, State Remote Sensing agency, Disaster Management Department, etc. to guide the ULBs, for both prior to the events as well as during the event.

[Action: MoUD and States/UTs]

In ULBs

ULBs will be responsible for the management of urban flooding at the local level. There are many challenges however, very often lack of coordination and sustained efforts, results in many shortcomings. These gaps need to be addressed. In view of this, and to make the ULBs better prepared, a DM cell will be set up at the ULB level. This cell will also specifically focus on UFDM. A senior officer in the rank of Additional Commissioner or an appropriate level will be responsible the nodal officer for this cell.

The major responsibilities of the UFC will be as follows:

i) Preparation and implementation of DM Plan,

ii) Coordination within the local body,

iii) Coordination with agencies outside the ULBs whose activities have a bearing on urban flooding (the list of all such agencies/orgainsations should be a part of the DM plan),

iv) Regular mock drills and preparedness exercises,

v) Conducting DM audit for all decisions, activities and investments which could have a bearing on DM, covering both structural and non-structural measures including techno-legal regime,

vi) DM audit of activities like construction of railway lines/roads/bridges/transmission towers, etc by other departments,

vii) Careful monitoring of operations and maintenance of stormwater drainage system and de-silting activities,

viii) Monitoring of activities like disposal of municipal solid waste and debris,

ix) Strengthening the involvement of local level orgainsations like RWAs, Bastis, Slum Associations, etc.,

x) Encouraging Community Based Disaster Preparedness (CBDP) efforts,

xi) Launching of awareness generation campaigns,

xii) Documentation of events,

xiii) Regular enhancement of capacity development at all levels, and

xiv) A local official will be designated as nodal officer at the ward level.

[Action: States/UTs and ULBs]

5.18 Participatory Planning

5.18.1 All the concepts that underpin the urban flood risk management framework are based on participatory principles. Traditionally, flood control has been driven by top-down decision making. Following the hierarchical structure of administrative systems, flood control measures are planned without the participation of the affected communities and other stakeholders. In many cases, this results in unsustainable measures which don't meet the needs of relevant stakeholders. In more severe

cases, exclusive top-down decision making can even lead to serious conflicts.

5.18.2 These shortcomings can be overcome by establishing participatory planning process as a basic principle in urban flood risk management. In this context, decision-making is understood as a combination of top-down and bottom-up approaches which enables the involvement of all stakeholders on the basis of equity. The process where the aspirations, concerns, capabilities and participation from local households to communities to local authorities to district and national institutions are adequately included in an iterative manner.

5.18.3 In order to ensure that all stakeholders have a possibility to be involved at some level of the decision making process, it is crucial for the success of the participation process to carefully identify stakeholders. This has to be done in an inclusive manner in order to prevent potential conflicts which may result from the exclusion of relevant stakeholders. In urban flood risk management relevant stakeholders may comprise:

i) The responsible municipal authorities,

ii) Citizens and communities which are affected by the implementation or non-implementation of measures (on- site as well as up- and downstream),

iii) River basin organizations/authorities,

iv) Regional development authorities,

v) Scientific institutions,

vi) The private sector, and

viii) NGOs.

5.18.4 The involvement of stakeholders meets three main goals. First, it brings knowledge from different perspectives together and thus enables a more profound understanding of flood risks. Second, members of affected communities have the chance to express the community's needs and to promote the integration of their demands in decision making. Finally, and based upon the first two goals, stakeholder involvement allows for the identification and implementation of flood management measures, which are effective and sustainable because the majority of stakeholders support them, although a consensus among all stakeholders can rarely be found, especially in cities, where spatial resources for flood mitigation are scarce, experiences shows that seriously practised participation is decisive for the mediation of conflicts. In urban areas, although there may be advantages of concentration of stakeholders as well as the medium of communication, there is always a shortage of time for participation in such activities. Particularly, in sub-urban areas, people have little time to spare from their livelihood engagements and time they perforce spend in travelling to their place of work. Special means have to be found to make use of the advantages and address the shortcomings. Further discussion on the constraints of stakeholder involvement and how representative form of participation can be achieved, are available elsewhere. In many countries, the private sector contributes significantly to the creation of physical and industrial infrastructure. In association with relevant national agencies, efforts must be made to develop and establish improved techno-legal procedures for disaster-resilient infrastructure. Private sector actors can particularly contribute to building resilient economies, infrastructure and communities

through the following disaster risk management activities:

i) Hazard and risk assessment,

ii) Awareness generation,

iii) Preparedness training and drills,

iv) Efficient logistics for rescue and relief operations,

v) Provision of trained engineers, architects and building artisans,

vi) Development and application of cost-effective hazard-resistant technologies,

vii) Involvement in the development of all-hazard warning and monitoring systems, and

viii) Development of risk transfer instruments.

5.19 Rapid Assessment Flood Inundation Mapping for Mumbai

A Rapid Assessment Flood Inundation Mapping for Mumbai

A rapid flood risk assessment for Mumbai is being carried out by the Indian Institute of Technology, Bombay, in association with MCGM, using best available data. The methodology uses conveniently available DEM data from public domain and rainfall intensities as a model input, which in turn provides a tool for a rapid assessment from limited data sources and provides reasonable results for planning purposes. As Light Detection and Ranging (LIDAR) survey data was still under process at the time of this study, 90-m resolution SRTM DEM has been obtained from Shuttle Radar Topography Mission (http://srtm.csi.cgiar) for this assessment. Global Mapper software has been used to develop contours at 1 m interval using SRTM DEM to identify the sub-catchment and low-lying areas. The runoff has been estimated using rational method for rainfall intensity of 50 mm/h and 100 mm/h for duration of 1 hour. It is assumed that the drains will adequately drain the runoff generated from rainfall intensity of 25 mm/h for which the existing system was designed. The runoff volume has been computed by summing up the volume between two successive contours to get the depth of inundation in the low-lying area. Further the habitation areas have been defined as slum, non slum areas and the spread has been calculated for both these areas. The location-specific flood risk has been determined. The flood risk assessment has been carried out for two scenarios - continuous rainfall at 50 mm/h for one hour and 100 mm/h for one hour. The inundation levels corresponding to these rainfall intensities are represented in the form of flood hazard map. The areas expected to be submerged by these rainfall intensities have been delineated. Subsequently the number of people likely to be affected by flooding in the ward has been estimated. This estimate will help in formulating mitigation measures like shelters, evacuation paths and planning for transport route diversions. More accurate results can be obtained with this methodology when better data becomes available.

5.20 Early Warning System for Urban Flood Management in Chennai

Early Warning System for Urban Flood Management in Chennai

An Early Warning System for Urban Flood Monitoring is being developed for Chennai by setting up a network of Automatic Weather Stations in selected micro watersheds for real time transmission of weather parameters to the Flood Control Room using GSM (Global System for Mobile Communication Standard) as a communication channel. In addition, the high resolution Airborne Laser Terrain Mapper (ALTM) acquired for Chennai City (as part of ongoing DST and Tamil Nadu State Govt., sponsored research project) is proposed to be used for modelling and simulating the inundation areas in real time for the catastrophic rainfall associated with cyclone activity in North East Monsoon. Also, ten IP cameras are proposed to be installed at important road junctions and vulnerable spots which will transmit the images of flood levels for validation of modelling results. Suitable hydrodynamic modelling software will be integrated with the data to simulate the inundation areas in real-time. A Decision Support System is proposed to be developed to relay advisory services regarding relief and rescue to planners/local municipal authorities. The Anna University Remote Sensing Centre is developing the system in association with the government of Tamil Nadu.

5.21 Urban Flood Impact Assessment for Hyderabad

A Pilot Project

Urban Flooding Impact Assessment - Hussainsagar Catchment, Hyderabad

Government of Andhra Pradesh in association with GHMC and NDMA have taken up a pilot study on "Urban Flooding Impact Assessment - Hussainsagar Catchment, Hyderabad". The main objective of the study is to develop a flood model for assessing the impact of riverine flash floods and vulnerability mapping of the flooding hazard in Hyderabad city. The output of the study is to come out with a set of recommendations, which would help to reduce/ eliminate the flooding vulnerability/ risk. The solutions/ recommendations can be linked with the existing master plans and it would help the city managers/ planners in handling flooding situations (such as cloudburst/ river overflow/ cyclone) when implemented over a period of time. The total geographical area proposed for the study is 330 sq km. The area is recurrently prone to flooding even for small quantity/intensity of rainfall. Due to this, the low-lying habitations along the main stream are persistently inundated and all the roads are flooding due to traffic. Data from the Doppler Weather Radar recently installed by IMD at Hyderabad will be calibrated by real-time data from the local network of rainfall gauges that will be established as a part of this study. The study will utilise a standard conceptual model for generating the flood in the catchment and full unsteady flow models (1 D Hydrodynamic Model) for channel routing to simulate the flood flows and flooded areas. These models will be used to prepare flood zoning maps for all frequencies of rainfall intensities.

6 Techno-Legal Regime

6.1 Overview

6.1.1 A pattern has been evolved over millions of years for the path to be defined for water to flow in streams, rivulets, tributaries and rivers and ultimately discharge into the sea. All known forms of life depend on water. Water is our lifeline it bathes us and feeds us. Civilisations started close to water sources – on the banks of rivers, in valleys, along the coastline. Every city/town falls within the basin, sub-basin, and watershed of a river system and receives rains.

6.1.2 In the beginning, the sites selected for habitation were on high ground, as they were considered safe, away from the flood plains. Over the ages, as civilizations grew in size, and towns and cities came into existence, there was pressure on land. This resulted in habitations spilling into floodplains and interfering with the flow of water.

6.1.3 Water will find its way, no matter what. When we interfere with its natural flow, it finds its own way and, that is why, flooding takes place. Growing urbanisation, resulting in a developed catchment, has added to the woes, as it translates into higher runoff as compared to an undeveloped catchment.

6.2 Town Planning in Ancient India

6.2.1 The earliest record of sound town planning in India dates back to the Indus Valley civilization. The excavations at Mohenjo-daro and Harappa establish that in those twin cities, sound town planning principles were in place, as evident from, not only the manner in which the roads were laid, but also by the consideration given to civic amenities, sewerage system and drainage. Besides, the houses were built with plinth rising above the street level. That perhaps could have been one of the earliest planned adaptation strategies to deal with flooding.

6.2.2 On the basis of a study of primary sources, available literature and archeological data in published reports from various sites, experts feel that town planning in India could probably be categorized into two periods. The mature period of Indus Valley Civilization that lasted between 2800 B.C. and 1700 B.C. The second period of Indian urban growth is generally supposed to have begun in 600 B.C., which coincides with the beginning of the early historic period in the Ganga Valley. The Study also reveals that several elements of planning, commonly used during the first period of urbanisation, were also found in the second period.

6.2.3 From then to the present age, we have not lived upto such a legacy that was inherited. This is not just typical of India, but it has been observed universally. This may give us some comfort, but certainly no respite, from the consequences of lack of foresight with respect to planning our cities and towns.

"Around a quarter of properties that were flooded in the UK in summer 2007 had been built in the last 25 years. A number of images of flooded properties from summer 2007 showed modern developments that had flooded. This reinforces the (Pitt) Review's conviction that strong controls on development on the floodplain are needed"

Pitt Review, 'Learning Lessons from the 2007 Floods', Chapter 5.5, page 62

6.3 Legal Support for Planned Development of Urban Areas

6.3.1 Management of urban flooding should aim at minimizing the exposure of communities to the adverse effects of flooding in cities and towns. The techno-legal regime can be a very useful tool in that direction. Master Planning, Zonal Planning, Development Country Regulations and Building byelaws provide the mandatory techno-legal framework for regulating the built environment.

6.3.2 Such laws are mainly state legislations as the State is competent to legislate and make laws on such subjects. However, in States and UTs such as Delhi, where land use is reserved with the Central Government. The Central Government is to legislate on such subjects and the Parliament is to make necessary laws.

6.4 Central Legislations/ Guidelines

6.4.1 Delhi Development Act - 1957

Taking this legislation as a model, state governments were guided to formulate the rules and regulations with the help of local bodies under various legislations. After approval, the local bodies enforced these rules and regulations pertaining to the development and building standards as building regulations/ building byelaws in their respective areas.

6.4.2 Model Town and Country Planning Act 1960

The Town and Country Planning Organization (TCPO), under the administrative control of MoUD, is the apex organisation to deal with the subject of planning (regional, urban and rural) and developmental policies. It formulated a Model Town and Country Planning Act in the year 1960 with the following provisions:

i) Provisions for preparation of comprehensive Master Plan for urban areas of various states. The states may adopt the model legislation with suitable modifications for this purpose,

ii) To constitute a Board to advise and to coordinate in the matter of planning and plan formulation by the Local Planning Authorities in the State, and

iii) Provisions for implementation and enforcement of the Master Plans and the miscellaneous provisions to achieve planned urban growth of various urban areas in the state.

6.4.3 Model Regional and Town Planning and Development Law 1985

The 1960 Act was revised in 1985 and this has largely been the basis for the enactment of comprehensive urban and regional planning legislation in States and UTs. This model is in the nature of a guideline and is the outcome of several reviews and revisions undertaken on

the recommendations of conferences of state ministers held from time to time. The legality of this model was confirmed by the Ministry of Law and Justice, GOI.

6.4.4 Model Urban and Regional Planning and Development Law 1993

A model Urban and Regional Planning and Development Law was also brought out, taking into account the provisions of 74th Constitutional Amendment Act (CAA), along with suggested changes in the Maharashtra and Gujarat Town Planning Acts.

6.4.5 Urban Development Plans Formulation and Implementation Guidelines 1996

In 1996, the Ministry of Urban Development, GoI, brought out the Urban Development Plans Formulation and Implementation (UDPFI) Guidelines. The Guidelines recommend an Urban Planning System consisting of a set of four inter-related plans as follows:

i) Perspective plan,

ii) Development plan,

iii) Annual plan, and

iv) Plans of projects and schemes.

6.4.6 National Building Code

6.4.6.1 The National Building Code of India (NBC), a comprehensive building code provides 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 work. The Code was first published in 1970 at the instance of the Planning Commission and then revised in 1983. Thereafter, three major amendments were issued, two in 1987 and the third in 1997.

6.4.6.2 Considering a series of further developments in the field of building construction, including the lessons learnt in the aftermath of a number of natural calamities, like devastating earthquakes and super-cyclones witnessed by the country, a project for comprehensive revision of NBC was taken up under the aegis of the National Building Code Sectional Committee, CED 46 of BIS and its 18 expert panels, involving as many as 400 experts. As a culmination of the Project, the revised NBC was brought out as National Building Code of India 2005, (NBC 2005).

6.4.6.3 Annex 1 of the comprehensive NBC, 2005 contains 11 parts, some of which are further divided into sections totalling 26 chapters. Annex 2 contains salient features of the revised NBC and includes, apart from other changes made, the changes especially with regard to further enhancing our response to meet the challenges posed by natural calamities and reflecting the state-of-the-art and contemporary applicable international practices.

6.4.7 Initiatives of the Ministry of Environment and Forests

6.4.7.1 The Ministry of Environment and Forests (MoEF) is the nodal agency in the administrative structure of the central government for planning, promotion, co-ordination and overseeing the implementation of environmental and forestry programmes.

6.4.7.2 Besides the Water Act of 1974 and Air Act of 1981, and other legislations, the Environmental (Protection) Act (EPA) was enacted in 1986. It is an umbrella legislation, empowering central government to take measures necessary to protect and improve the quality of the environment by setting standards

for emissions and discharges; regulating the location of industries; management of hazardous wastes, and protection of public health and welfare. Certain initiatives of MoEF are relevant in the context of urban flooding.

6.4.7.3 Under this Act, MoEF issued the Municipal Solid Waste (Management and Handling) Rules, 2000, notified on 25th September 2000, in exercising of the powers conforming to section 3 and 25 of EPA. The MSW Rules provide a framework encompassing collection, transportation, treatment and disposal of municipal solid waste. These rules are complemented by the existing Biomedical Waste Rules of 1998 and Hazardous Waste Rules of 1989 respectively, whereby disposal of these wastes, along with usual urban municipal waste, is prohibited.

6.4.7.4 Environmental Impact Assessment

EIA is one of the proven management tools for incorporating environmental concerns in the development process and also in improved decision-making. The growing awareness over the years on environmental protection and sustainable development has further laid emphasis on sound environmental management practices. The programme of EIA, in vogue in MoEF for the last two decades, was initiated with the appraisal of river valley projects. The scope of appraisal was subsequently enlarged to cover other sectors like industrial projects, thermal power plants, mining schemes and infrastructure projects. EIA was made mandatory for 32 categories of development activities on the basis of EIA Notification S.O. 60(E) dated 27th January 1994.

This was further amended vide S.O. 801 (E) dated 7th July, 2004. This brought within its purview new projects related to construction of townships, industrial townships, settlement colonies, commercial complexes, hotel complexes, hospitals, office complexes for 1000 persons and above, or discharging sewage of 50,000 litres per day and above, or with an investment of ₹ 50 crores and above, and new industrial estates having an area of 50 hectares and above, etc.

i) Stormwater drainage concerns will be made a part of all EIA norms, and

ii) Sometimes to overcome compliance to EIA, projects are split into smaller areas. Guidelines will be issued to State EIA Authorities to subject even smaller projects to meet EIA norms.

[Action: MoEF, MoUD, States/UTs

6.4.8 State Level Legislation

6.4.8.1 Planning and development are state subjects and therefore, the development in the states is based on the legislative support as applicable in that state. The legislative support in the state is applicable to formulate Master Plans, Zonal Development Plans and Area Planning lay-outs for their implementation and enforcement.

6.4.9 Legislative Support at the Local/ Municipal Level

6.4.9.1 At the local level, the Municipal Authorities and Panchayats regulate the development/construction of buildings through the building byelaws as followed in their respective areas. The State Governments/UTs from time to time issue directions/guidelines for safety against natural hazards, which are followed by local bodies while granting permission for construction of buildings/ structures.

6.5 Study by Experts Committee (2004)

6.5.1 A National Core Group, set up by the MHA on earthquake mitigation, suggested that the State Town and Country Planning Act as well as Zoning regulations be reviewed so as to ensure that these are in conformity with the mitigation requirement. MHA constituted a Committee to look into this in January 2004.

6.5.2 The Committee studied the Model Town and Country Planning legislations framed during 1960, based on which most of the State Town and Country legislations are enacted. The Committee also studied the revised Model Regional Town Planning and Development Law 1985 framed by Town and Country Planning Organisation, Ministry of Urban Development and Poverty Alleviation, and UDPFI Guidelines. Model Urban and Regional Planning and Development Law was formulated, keeping in view the earlier Model Planning Legislation and incorporating various provisions of 73rd and 74th Constitution Amendments.

6.5.3 The Committee proposed amendments in the above-mentioned documents, by incorporating the various terminologies pertaining to natural hazards, natural hazard proneness and mitigation under the relevant sections and included the hazards due to earthquakes, cyclones, floods, and landslides. Amendments were suggested to take note of the natural hazard mitigation, while formulating the development plans for various levels like perspective plan, development plan, zonal development plan and area plan. Additional provisions have also been suggested for formulating the regulations for land use zoning and development control/building regulations with regard to natural hazard mitigation.

6.5.4 The detailed recommendations were made for additional provisions to be incorporated in the development control regulations for safety in natural hazard prone areas and the building byelaws for structural safety. Details of various BIS codes, relating to structural safety for natural hazards are given for the guidance of the professionals to design the structures/buildings, keeping in view the provisions of such codes against different natural hazards.

6.5.5 The Committee observed that there are large areas where Town Planning Legislation and Development Control/Building byelaws are not applicable and the sanctioning authority is the Development Commissioner through Central Public Works Department (CPWD)/ PWD or other such agencies. Therefore, the Committee recommended that in such areas, the sanctioning authority should be advised to take into consideration provisions regarding the structural safety in natural hazard prone areas while sanctioning development/projects in such areas, under their respective legislation.

6.6 Subsequent Amendments

The Experts Committee had proposed amendments to rules and byelaws, relating to Layout Approvals and Building Permissions, to address DM related issues. Many states have incorporated and amended their rules and bye-laws but all states are not on par in doing this. Salient features of the amended rules and bye-laws having relevance to urban flood management are included below, under both the categories.

6.6.1 Layout Approvals

- **Minimum requirement for approval of Layout**

  i. The Layout proposal shall conform to the following requirements:

(a) Shall have approach through an existing road, the width of such shall not be less than 12 m (in case of land-locked plots, the owner has to ensure the approach road through neighbouring lands accordingly),

(b) Minimum width of proposed roads in the layout shall be 12 m for residential in Gram Panchayats and 18 m in other areas and non-residential layouts. Notwithstanding the above minimum width, the Executive Authority may insist upon larger road widths depending upon local conditions or importance of any particular road, etc. The width of the roads in the layouts shall be in conformity with the General Town Planning Scheme or the Master Plan, if any in force,

(c) Minimum open space set apart in the proposed layout for playground/park/educational institution or for any other public purpose shall be at the rate of 10% of the total site area,

(d) The minimum plot size for non-residential layouts shall be 300 sq m except in case of Commercial or Mercantile buildings for which the minimum plot size shall be 18 sq m, and

(e) The applicant should provide a service road of minimum 12 m width for the layout if the land is abutting to National Highway having less than 60 m width.

- ### Required specifications and conditions

i) The owner of a site shall undertake the following works under the supervision of Executive Authority with the surveyors after intimation of the layout approval by the Executive Authority:

a) Levelling with suitable gradient and formation of all roads with sub-surface, kerbstones, metalling of the carriageway, side drains as per specifications mentioned in the rules,

b) Construction of drains and channelization of nallahs/ stormwater drains for allowing stormwater runoff. These may be channelised in such a way as to conserve or harvest the water in the nearest water body or public open space, etc,

c) Undertake plantation in the layout including avenue plantation, in public open spaces, etc,

d) Fencing of open spaces, and

e) Unless the conditions specified above are fulfilled, the owner shall not be entitled to utilize, sell, lease or otherwise dispose of the land or any portion thereof.

ii) The following works shall be undertaken through the Executive Authority upon payment of proportionate charges at a later date:

(a) Street-lighting and electricity facilities, and

(b) Provision of disposal system and protected water supply system.

- **Restrictions of building activity in the vicinity of certain areas**

i) No building activity shall be allowed in the bed of water bodies like river, lake, pond or nallah/ stormwater drain, etc, and

ii) No building activity shall be carried out within :

a) 50 m from the boundary of rivers and lakes of surface area for 10 Ha and above,

b) 30 m from the boundary of lakes of surface area for less than 10 Ha, and

c) 12 m from nallahs, canals, etc.

- **Rainwater Harvesting**

i. Every building proposed for construction shall be provided with required facilities and infrastructure for conservation and harvesting of rainwater, and

ii. Percolation pits or Trenches.

The paved surface around the building shall have percolation pits or trenches or combination of pits and trenches in such a way that total volume of such structure shall not be less than 6 cubic m for each 100 sq m of roof-top area and multiples thereof. Depending on the geomorphologic and topographical conditions, the pits can be of size 1.2 m wide x 1.2 m long x depth of 2 to 2.5 m. The trenches can be of width of 0.6 m x length of 2 to 6 m x depth of 1.5 to 2 m. Terrace water shall be canalized through pits and/or trenches. The pits shall be backfilled with filter media comprising of the following materials.

(a) 40 mm road metal as the bottom layer upto 50% of the depth,

(b) 10 mm road metal as the lower middle layer upto 20% of the depth,

(c) Coarse sand as the upper middle layer upto 20% of the depth,

(d) Top 10% of the pits/trenches will be empty and a splash pad is to be provided in such a way that roof-top water falls on the splash pad,

(e) Brick masonry wall is to be constructed and cement mortar plastered on the exposed surface. The depth of the wall below the ground shall be such that the wall prevents loose soil going into pits/trenches. The projection of the all above ground should be minimum of 15 cm, and

(f) Perforated concrete slabs shall be provided on pits and trenches.

iii Terrace water collection

a) The terrace shall be connected to a sump or the wall through a filtering tank by P.V.C. pipe. A valve system shall be incorporated to enable the first part of the rain-

water collected to discharge out to the ground, if it is dirty, and

b) A filtering tank, measuring 1m X 1m X 1m, can be constructed near the sump. The tank can be divided by a partition slab and one part shall be filled by fine sand and other by coarse sand. The bottom portion of the tank should have a slope to avoid stagnation of water.

iv. Open Ground

Wherever there is an open ground, the top soil shall be removed over a portion of the ground and back filled with coarse sand to allow percolation of rainwater. Any other methods, proved to be effective in conservation and harvesting of rainwater, may be adopted in each and every construction taken up.

v. The proposal shall comply with the provisions of relevant regulations in force.

vi. In case the layout area exceeds 50 Ha, the NOC from Central Pollution Control Board/ MoEF is mandatory.

6.6.2 Building Permissions

- **Restrictions of Building Activity in Vicinity of Certain Areas**

i) No building/ development activity shall be allowed in the bed of water bodies like river or nallah/ stormwater drain and in the Full Tank Level (FTL) of any lake, pond, tank or pond/ tank bed lands,

ii) The above water bodies and courses shall be maintained as recreational/ green buffer zone, and no building activity other than recreational use, shall be carried out within:

a) The Coastal Regulation Zone (CRZ) restricted area in case of areas along the sea coast,

b) 100 m from the river edge outside Municipal Corporation/ Municipal limits and 50 m within Municipal Corporation/ Municipal limits. No permanent constructions/ structures will be permitted within the above-mentioned buffer zone,

c) 50 m from the boundary of lakes of area 10 Ha and above,

d) 30 m from the boundary of lakes of area less than 10 Ha / ponds/ tank bed lands,

e) 12 m from the boundaries of major canal, stream, etc.,and

f) 2 m from the defined boundary of nallahs/ stormwater drains, etc. The above shall be in addition to the mandatory setbacks. Unless and otherwise stated, the area and the FTL of a lake/ pond shall be reckoned, as measured or given in the Survey of India topographical maps/Irrigation Department records/ Revenue records. The above buffer zone may be reckoned as part of the building setback.

iii) Unless and otherwise specified in the Master Plan/Zonal Development Plan:

a) The space to be left in and around the major canal/ stream (including the actual canal/ stream bed width and alignment) shall be minimum 12 m. This may be developed as Green Buffer/recreational and / or utilized for road of minimum 9 m width, wherever feasible,

b) In case of lakes of area 10 Ha and above, in addition to development of recreational/ green belt along the foreshores of a lake, a ring road or promenade of minimum 12 m may be developed, wherever feasible; while in respect of foreshores of river, a river drive road of minimum 18 m may be developed in the said 50 m buffer zone, and

c) The above greenery/landscaping and development shall conform to the guidelines and provisions of the NBC of India, 2005.

- **Minimum Setbacks and Height Stipulations for all Types of Non-High Rise Buildings (buildings below 15 m height, inclusive of stilt/ parking floor):**

i) A strip of at least 1 m greenery/lawn along the frontage of the site within the front setback shall be compulsorily developed and maintained with greenery and trees,

ii) For plots above 200 sq m in addition to 1 m greenery / lawn along the front age of the site with the front setback, a minimum 1 m wide continuous green planting strip in the periphery on remaining sides are required to be developed and maintained as greenery and trees within the setback. Rainwater harvesting structures shall be provided in the prescribed manner within the setbacks,

iii) For all residential/institutional/industrial plots above 750 sq m, in addition to 1 m greenery/ lawn on all four sides, 5 % of the site area has to be developed as tot lot/landscaped area and trees planted and maintained. Such organized open space could be in more than one location, shall be open to sky and shall be of a minimum width of 3 m, and

iv) If the above greenery is not provided and maintained and rainwater harvesting structures are not provided, 10% of additional Property Tax every year would be imposed as penalty by the sanctioning authority, till the said condition is fulfilled.

- **Provision of Tot Lot and Greenery**

i) In every high rise building site, an organized open space which shall be utilized as greenery, tot lot or soft landscaping, etc. shall be provided over and above the mandatory open spaces to be left in and around the building. This space shall be at least 10% of total site area and shall be of a minimum width of 3 m. This may be in one or more pockets and shall be open to sky,

ii) In addition to the above, a minimum 2 m wide green planting strip in the periphery on all sides within the

setbacks are required to be developed and maintained with greenery and trees in all high rise building sites, and

iii) Rainwater harvesting structures shall be provided in the prescribed manner within the setbacks.

- **Grant of Transferable Development Right:**

  Grant of Transferable Development Right may be considered by the Competent Authority for the following areas subject to the owner complying with the conditions of development above, as per the following norms: for conservation and development of lakes/ water bodies/ nallahs/ stormwater drains, foreshores and recreational buffer development with greenery, open spaces earmarked in Master Plan, etc: equivalent to 50% of built up area of such area developed at his/ her cost.

- **Requirements of Group Development, Group Housing/ Cluster Housing/ Residential Enclaves and Row Housing Schemes.**

  Minimum of 10 % of site area shall be earmarked for organized open space and be utilized as greenery, tot lot or soft landscaping, etc. and shall be provided over and above the mandatory open spaces. This space may be in one or more pockets and shall be open to sky.

- **Incentives for Owners Leaving More Setbacks/ Installing Solar Heating and Lighting System/ Rain Water Harvesting/ Recycling of Waste Water**

  An incentive of 10% rebate in Property Tax will be given by the local authority for owners or their successors-in-interest who undertake both recycling of waste water and rainwater harvesting structures.

- **The proposal shall comply with the provisions of other relevant regulations in force.**

- **In case of buildings exceeding built up area of 1,50,000 sq m. No Objection Certificate from Central Pollution Control Board/MoEF is mandatory.**

MoUD will play a key role in coordinating the efforts of the states regarding the compliance with Techno-Legal Regime by all the ULBs in their respective states.

i) Review the present status and bring all states on par relating to making amendments to development control regulations and building byelaws on the basis of the recommendations of the Experts Committee, set up by MHA in 2004,

ii) Issue guidelines for setting up a standing mechanism for a regular review to suggest periodic changes based on lessons learned and experiences and BMPs within and outside the country,

iii) Issue guidelines for making the techno-legal framework as an essential part of technical capacity development at all levels of state governments and ULBs, besides all other stakeholders,

iv) Prepare guidelines for mandatory third party compliance review of all land use and developmental plans, involving experts from local S&T and Academic institutions,

v) Prepare necessary guidelines for evaluating cities/towns to be considered for annual awards for best record of compliance with techno-legal regime. Cities/ towns will be considered under different categories like metros with 4 million plus population, cities with one million plus (less than 4 million) population and cities with less than one million population. Besides, smaller municipalities should also be considered under two or three categories,

vi) Review procedure for licensing architects, with emphasis on compliance with techno-legal regime, and

vii) Sanction of new projects to States/UTs, linked to proper implementation of techno-legal regimes by the ULBs.

[Action: MoUD/TCPO, States/UTs and ULBs]

6.7 Urban Sprawl

6.7.1 With increased urbanisation, more and more towns and cities are witnessing a change in the land use not only within the urban areas but also along the highways and in the immediate vicinity of the cites/towns. This dispersed development outside of compact urban and village centres along highways and in rural countryside is defined as urban sprawl.

6.7.2 When rural pockets are connected to a city by a road, in the initial stages, development is concentrated along such roads in the form of service centres such as shops, dhabas, etc., which eventually become the hub of economic activities leading to the sprawl. This type of upsurge caused by a road network between urban/ semi-urban/ rural centres is very much prevalent and persistent in most places in India. These regions are devoid of any infrastructure, since planners are generally unable to visualise such growth patterns. This growth is normally left out in most government surveys including the census enumeration as this cannot be grouped under either urban or rural centre.

Growth of urban sprawls will result in change in land-use and land cover with impacts such as loss of agricultural land, open space, and ecologically sensitive habitats. This will ultimately have future implications in terms of urban flooding. All such concerns will be addressed by the states on a priority basis. MoUD will review this with the states/UTs.

Action: MoUD, States/UTs

7 Response

7.1 Overview

Response measures, taken immediately prior to and following an event, become very crucial in saving lives and protecting property. For effective response during urban flooding, it would be important for all stakeholders to have a clear understanding about its adverse impact and the response actions that have to be taken. It is essential to define the roles of all the agencies involved and this will have to be a part of the DM Plan for the city/town.

7.1.1 Adverse Impacts of Urban Flooding

7.1.1.1 Localised Impacts

Importance of urban centres has been very well brought out in Introduction (Chapter 1). Urban flooding has localised impacts on commercial, industrial, business and institutional locations, as well as different categories of residential areas. Besides, there are disruptions of water supply, sewerage, power supply and communications.

i) Impact on commercial, industrial, business and institutional locations

   a) Shutdown of commercial, industrial and business activity and loss to property and assets depend upon the severity of flooding and vulnerability of the sites. Very often, they are covered by insurance and, as a result, they are able to recover losses,

   b) Some of the stakeholders falling under this category depending upon size and managerial capability may have their own DM Plan and contingency planning, and

   c) Likewise, some of them may have their own insurance cover, enabling them to recover at least major part of their losses and aid resilience.

Steps will be taken for business continuity plan by local Federations of Commerce and Trade and organisations like CII, FICCI, ASSOCHAM and NASSCOM. State governments should coordinate these efforts.

[Action: States/UTs]

ii) Impact on different categories of residential areas:

   a) Colonies with approved layouts,

   b) Developed slums with some basic infrastructure,

   c) Unapproved layouts of small colonies, bastis, habitations and new/undeveloped slums,

d) New slums coming up in areas, which are not approved, and

e) Clear encroachments upon nallahs, drains and houses constructed in flood plains including high flood levels of rivers and below FTL of water bodies. While housing in unapproved/ irregular layouts and encroachments can be more vulnerable to flooding, even approved layouts which have not initially taken flood vulnerability into consideration, also get very badly affected.

7.1.1.2 General Impact

i) Disruption of traffic – road, railway and air traffic,

ii) Schools, hospitals, and

iii) Water supply, sewerage, powers and transmission lines, communication and other infrastructure.

7.2 City Disaster Management Plan

7.2.1 A City Disaster Management Plan (CDMP) is a very important and basic DM document and takes into account all the disasters that a city is vulnerable to. Going by past records and experiences it can sometimes be presumed that some urban areas are less vulnerable to flooding. However, every city has to factor in urban flooding concerns, even if they are varying in degrees, keeping in view different factors that contribute to urban flooding that have been discussed in these guidelines.

CDMPs will be prepared taking into account UFDM concerns.
Action: States/UTs and ULBs

7.3 Response Actions

7.3.1.1 Taking into consideration the possible adverse effects of urban flooding including localized and general effects, every local body should have a robust response plan to deal with such an event. Central to all this is to have a CDMP. Besides, this has been discussed in detail in Chapter 5. It has been categorically stated that all DM actions should be planned, executed and monitored, on the basis of local watersheds and not be guided or restricted by administrative boundaries.

7.3.1.2 While a CDMP takes into consideration all disasters that the city is vulnerable to – both natural and man-made, it should cover all issues relating to urban flooding disasters. Some of the essential elements to be taken note of regarding response are discussed here.

7.3.2 Emergency Operation Centre

7.3.2.1 Emergency Operation Centre (EOC) is an off-site facility which will be functioning from headquarters of the ULB. It should be an augmented control room having communication facilities and space to accommodate the various Emergency Support Functionaries. These officials will be able to take decisions on the spot, under the guidance of the Responsible Officer (RO) and will be able to assist the RO in achieving the incident objectives. The responsibility can be discharged most effectively only if it has the required information through a fail-safe communication facility and an ideal information technology solution with DSS. In additions to the above, a web-based

connectivity will further help in accessing situational awareness, decision support and multi-agency coordination. It will allow all collaborating decisions, activate plans, deploy Incident Response Teams (IRTs), perform and log all necessary response and relief activities and make the EOC effective. It is very important to put the above capabilities in place.

7.3.3 Incident Response System

For effective response, the following facilities may be required to be established, depending on the needs of the incident, the length and time the facilities needed to be used, the cost to establish it and prevailing weather conditions, etc.

7.3.3.1 Responsible Officer

In view of the provisions of the DM Act 2005 and the administrative structure existing in the country at the District and State levels, the roles of the Chief Secretary and the District Magistrates/ District Commissioner is all-encompassing as regards response. Under the Incident Response System (IRS) it is necessary to designate an authority responsible and accountable by law to respond to disasters and therefore a position of RO has been introduced. Incident response management may however not always require the direct intervention of the RO. On the ground, the management will be done by the Incident Commander (IC) to whom powers will have to be delegated by the RO. In the context of urban flooding, the Commissioner / CEO of the ULB could be designated the RO, if the DM/ Collector is a junior officer and will be overall responsible for all response activities during any incident or crisis.

7.3.3.2 Incident Commander

The IC is the overall in-charge for the management of on-site response to any incident. He is appointed by the RO. He may have a deputy with him depending upon the magnitude and nature of the incident. He may be assisted by officials and staff, responsible for performing different duties.

7.3.3.3 Incident Response Teams

The RO will constitute IRTs from among officers from the concerned departments of the ULB besides Fire and Emergency Services, etc. The Members of IRTs will be properly trained and sensitised regarding their roles during the pre-disaster phase itself. Officers in charge of Stormwater Drainage and Water and Sewerage will be part of the IRTs. The headquarters of IRT will provide continuous support to the on-scene IRT(s) and, if required, join them or take over response on the direction of the RO.

7.3.3.4 IRS facilities – Incident Command Post

The Incident Command Post (ICP) is the location at which the primary command functions are performed and shall have one IC in-charge there. There will be only one ICP for each incident. For the initial location of the ICP, the nature of the incident, whether it is growing or moving and whether the ICP location will be suitable in size and safe for the expected duration of the incident, should be taken into consideration. Larger and more complex incidents will require larger ICP.

The ICP may be located at a safe building near the incident. In case of non-availability of such a building, the ICP may be located in a vehicle, trailer or tent. It should however have adequate lighting, effective communication system and other such facilities so that one can function effectively. In such a situation, the other components of IRT may function from a convenient location and the

ICP should be in constant and regular touch with them.

i) Officials will be designated by name at all levels, to discharge various responsibilities under the IRS, and

ii) List of these pre-designated officials with telephone numbers will be given wide publicity through media and other printed publicity material, to be freely made available to all stakeholder groups.

[Action:ULBs]

The National Disaster Management Guidelines on Incident Response System, prepared by NDMA, was released in July 2010. The Guidelines can be accessed at http://ndma.gov.in/ndma/guidelines.htm

7.4 Emergency Response

7.4.1 Evacuation Plan

7.4.1.1 There shall be a ward-wise inventory of vulnerable areas and an evacuation plan, should it become necessary to shift people to safer places. In case of sufficient early warning, this could be put in operation prior to incident. However, if it is a sudden onset event, emergency evacuation will be carried out at the shortest notice and may continue as severity increases.

Emergency evacuation plans will be developed with an institutional checklist of emergency actions.

[Action: ULBs]

7.4.2 Flood Shelters

7.4.2.1 Depending upon the severity and magnitude of the flood, people from the affected areas are required to move to safer places. While some may have space available in the upper floors/ terraces, some may move to houses of friends and relatives. However, very often the poorest are the most vulnerable and in the absence of any such possibility, they will have to be moved to flood shelters.

7.4.2.2 School buildings or community halls may generally be identified for such purposes. Water supply and sanitation facilities may not be sufficient to meet the needs of the people who are shifted to shelters. Additional temporary arrangements may have to be planned even in advance, depending upon the local conditions.

i) Buildings will be designated as Flood Shelters and all necessary arrangements will be ensured ahead of the flood season, and

ii) Additional temporary arrangements will be made for water, sanitation, etc.

[Action: ULBs]

7.4.3 Search and Rescue

7.4.3.1 In any emergency, even before the intervention of the state machinery, community becomes the first responder at the local level. The community plays a major role in preventing loss of life and damage to property. So, community-based disaster preparedness (CBDP) and response are very important aspects of urban flood disaster management.

7.4.3.2 However, the Local Emergency Squads, Fire Brigade and the Disaster Response Force, etc. have a very important role to play in search and rescue efforts.

i) Community level teams will play an important role in planning and assisting in this and work in coordination with the official machinery, and

ii) The municipal staff also works in close coordination with revenue administration.

[Action: ULBs]

7.4.4 Food and Water Supply

7.4.4.1 Food and water for people evacuated to Flood Shelters should be given top priority. Further, whenever people are stranded at other locations, they should also be provided food and other essential commodities. Water shall be supplied to people to whom the regular water supply is affected due to flooding. Urgent steps should be taken to restore water supply on war footing after the event.

7.4.5 Sanitation

7.4.5.1 For disposal of solid waste, a container has to be provided at the shelter place. Water supply and sanitation facilities may not operate during the floods, or may not be sufficient to meet the needs of those people that are shifted there.

Children, women, the aged and differently-abled persons will be given special attention.

[Action:ULBs]

7.4.6 Flood Hotspots

7.4.6.1 Every city or town has certain flood hot-spots which are chronic spots of inundation, affecting smooth flow of road traffic and at times even rail traffic. These can change over a period of time. While efforts are made to reduce the hotspots through mitigation measures, new hot-spots may be detected due to various activities affecting local hydrology.

i) Pre-flood season mitigation measures will be taken, and

ii) Post-flood review and identification of any fresh hot-spots will be done on a regular basis.

[Action: ULBs]

7.4.7 Chronic Flooding Areas

7.4.7.1 Urban areas have chronic flooding spots, which are usually low-lying areas, which may be falling in floodplains or within the FTL. People belonging to the marginalised sections predominantly live there in slums, etc. There are also a large number of instances of colonies and lay-outs, inhabited by even affluent sections that have come up in such areas.

These spots should be properly identified in the CDMP and response actions planned well in advanced, taking both the physical and social vulnerability into account.

Action: ULBs

7.4.8 Emergency Logistics

7.4.8.1 Inflatable motorised boats, helicopters and search and rescue equipment is required immediately after an urban flood event to carry out search and rescue of people trapped in inundated areas, on tree tops and hanging on to structures. The ULBs have to compile a list of such equipment and identify suppliers of such specialised equipments and enter into long term agreements for their mobilisation and deployment in the event.

7.4.8.2 The setting up of relief camps for the people whose houses have been damaged by flood, the provision of basic amenities in such camps involves complex logistics of mobilising relief supplies, tents, water supply and sanitation systems, transport and communication systems, and medical supplies. Immediate restoration of power supply would be essential to carry out relief operations. An information booth for victims would be established by the authorities of ULBs.

7.4.9 Relief Camps

7.4.9.1 Relief camps may be set up for a slightly long-term use of the people whose houses have been damaged by floods and can not be made usable in a short span of time. The provision of basic amenities in such camps involves complex logistics of mobilising relief supplies, tents, water supply and sanitation systems, transport and communication systems, and medical supplies.

7.5 Specialised Response Teams

7.5.1 NDRF and SDRF

7.5.1.1 As already discussed in Chapter 2, NDRF is a highly specialised force and available as when requisitioned by the RO. In fact, in case of an impending disaster, they can also be pre-positioned at the vulnerable places. Besides the NDRF, states are required to raise the SDRF and, as and when they become operational, they could be requisitioned, as required.

Periodic simulation exercises and mock drills will be organised and made mandatory on the lines of pilot initiatives of NDMA for ensuring effective, functional emergency response, along with the inventory of community resources and assets.

[Action: States/UTs and ULBs]

NDRF's Capacity for Evacuation

(12 hrs operation within the area of 5 km radius)

The total number of existing NDRF Bns is eight and two new NDRF Bns have also been sanctioned.

Evacuation capacity of 01 NDRF Bn:

(A) No. of **Inflatable Boats** in each NDRF Bn – 72
Rescue Capacity of each Boat – 08 (excluding drivers/ rescue personnel)
No. of evacuation trips in 12 hrs – 24 (time taken in one trip ½ an hr)
No. of people evacuated in 12 hrs – 72 x 08 x 24 = 13,824

(B) No. of **Fibre Boats** in each NDRF Bn– 06
Rescue Capacity of each Boat – 18 (excluding drivers/ rescue personnel)
No. of evacuation trips in 12 hrs – 24 (time taken in one trip ½ an hr)
No. of people evacuated in 12 hrs – 06 x 18 x 24 = 2,592

(C) No. of Boat Assault Universal Type (**BAUTs)** in each NDRF Bn – 36
Rescue Capacity of each BAUT – 18 (excluding drivers/ rescue personnel)
No. of evacuation trips in 12 hrs – 24 (time taken in one trip ½ an hr)
No. of people evacuated in 12 hrs – 36 x 18 x 24 = 15,552

Evacuation in 12 hrs by one NDRF Bn = A + B + C = 13,824 + 2,592 + 15,552 = 31,968

Evacuation in 12 hrs by 08 NDRF Bns = 31,968 x 08 = 2,55,744

Total Evacuation in 12 hrs by 10 NDRF Bns = 31,968 x 10 = 3,19,680

7.5.2 Police and Home Guards

7.5.2.1 The Police play a very important role, especially during and immediately after an urban flooding event, in managing traffic, assisting in search and rescue, transportation and certification of casualties besides maintaining law and order in general. The Home Guards, the auxiliary arm of the Police force, shall support the administration in various disaster response tasks.

7.5.3 Fire Brigade

7.5.3.1 Traditionally in India, fire services were trained and used for fire-fighting operations. However, their mandate covers a wider range and they are also called Fire and Emergency Services in many states. Fire service is a state subject and a responsibility of the local municipality. At present, there is no uniformity in the administration for fire services in India.

7.5.3.2 As per the Standing Fire Advisory Council of India, the response time in urban areas should be 3-5 minutes. There is a major gap in the number of fire stations, fire-fighting and rescue equipment and trained personnel. This problem needs to be addressed on an urgent basis. This will not only be useful to deal with urban flooding, but all other urban disasters and emergencies.

7.5.3.3 In Mumbai, the Mumbai Fire Brigade is administered by the MCGM and looks after rescue and relief of all kinds of disasters, but in many states the fire and emergency services are under the control of the state government. Mumbai Fire Brigade has demonstrated its capability in dealing with all disasters, including urban flooding in 2005, during which they saved the lives of thousands of people.

i) Since Fire is a municipal subject, a uniform policy is required which will be applicable in all states. Steps will be taken by all the States/UTs to have the fire services under the Municipal Corporation/ Municipality, for at least the larger cities/ towns,

ii) States/ UTs will take necessary steps to systematically strengthen fire services by making provisions in their annual plans, and

iii) The 13th Finance Commission recommended that a portion of the grants provided to the ULBs be spent on revamping of the fire services within their respective jurisdictions. These bodies could provide financial support to the State Fire Services Department towards this objective. In this process, ULBs could draw upon the expertise of state agencies and the NDMA, as required.

[Action: MoUD, States/UTs and ULBs]

7.5.4 Local Emergency Squads

7.5.4.1 Every city/town faces emergencies, all round the year, and the ULBs have emergency squads to deal with them. Urban flooding is also an emergency, occurring frequently. Local Emergency Squads need to be constituted at the ward level. A highly localised event can be fully taken care by the Emergency Squads.

i) The emergency squads will be oriented to deal with such situations and will be provided with necessary training and equipment as mentioned in the DM Plan, and

ii) Equipment will invariably include pump sets of required capacities in sufficient numbers.

[Action: ULBs]

7.6 Medical Preparedness and Response

7.6.1 Preparedness

7.6.1.1 City hospitals should be adequately prepared to handle cases of flood-affected disasters and medicines for monsoon disasters.

7.6.1.2 In the event of an urban flood disaster, death could be due to drowning, injuries sustained due to damage to infrastructure like wall collapse, etc. Water borne diseases could immediately affect the people as a skin disease and vomitting. These incidences will also lead to outbreak of epidemics and skin diseases due to wading in flood waters and infection due to water borne diseases, such as dengue and malaria. Leptospirosis can be a serious threat, as people wading through water may get affected. Hospitals should have stocks of antibiotics and be in a position to requisition them at short notices.

7.6.1.3 Diseases like malaria and dengue spread, if adequate sanitation and disinfection was not carried out. Cholera is also a possibility, because of the conditions that may be conducive for it. The important drugs are chlorine tablets.

7.6.1.4 The supply of safe and sufficient drinking water needs to be ensured. Protecting existing water sources from contamination, adding chlorine tablets in water for residual disinfection and provision of latrines and proper waste disposal to avoid contamination through flies and other insects, are important steps required immediately in the aftermath of an urban flood. Vector control is done by spraying of shelters with residual insecticides. Provision of insecticide-treated mosquito-nets and larviciding are recommended. Immunisation needs to be carried out in susceptible individuals to prevent diseases. Necessary arrangements should also be made to dispose off animal carcasses.

Local scale emergency medical response systems will be established to deal with medical preparedness, emergency treatment, mortuary facilities and disposal of bodies and carcasses, public health issues including trauma and control of epidemics.

[Action: States/UTs and ULBs]

7.6.2 Emergency Medical Response

i) On-site arrangements should be in place for treatment of minor ailments and injuries,

ii) Hospitals shall be identified in every ward for emergency treatment,

iii) Adequate arrangements should be provided for people requiring psycho-social care, in the aftermath of a disaster, and shall be continued for an extended period of time in case of serious cases,

iv) In the event of casualties, the local body will develop systems for proper identification of the dead, recording the details of victims, and making use of DNA fingerprinting,

v) Mortuary facility and disposal of the dead, and

vi) Public Health Issues.

i) Risk knowledge will be linked with local scale response plans by organizing necessary support systems from national agencies in accordance with needs of the local authorities and community stakeholder groups, and

ii) Institutionalised multi-agency collaboration will be developed with clarity of roles and responsibilities from city to ward levels and periodic updating of SOPs at different levels based on experience gained.
[Action: States/UTs]

The National Disaster Management Guidelines on Medical Preparedness and Mass Casualty Management, prepared by NDMA, was released in November 2007. The Guidelines can be accessed at http://ndma.gov.in/ndma/guidelines.htm

7.7 Involvement of the Corporate Sector

7.7.1 The corporate sector plays a very important role after a disaster by providing resources and equipment. The corporate sector will be encouraged to take proactive role during mitigation and preparedness phase. They will be encouraged to sensitize their employees and also to develop suitable business continuity plans to ensure disruption-free operation following a disasters. As a part of Corporate Social Responsibility (CSR), the corporate sectors operating in urban areas will be encouraged to campaign on prevailing urban flood risk and preparedness thereof, among vulnerable communities in the vicinity of their locations.

7.7.2 ULBs will facilitate involvement of the corporate sector in making available their services and resources to the Government during the immediate aftermath of urban flood. The Corporate sector, as a part of the Corporate Social Responsibility, can provide *inter alia* the services of hospitals, power and telecommunication, relief supplies, search and rescue equipment, transport and logistics for movement of relief supplies to the extent possible and technical services for restoration and reconstruction of damaged infrastructure. For instance, the Construction Federation of India with the support of Hindustan Construction Ltd. has set up the India Disaster Response Network (IDRN), which can also be associated during response, restoration and recovery phase. ULBs will develop appropriate mechanism to receive and optimally utilise all such assistance.

7.7.3 Recognising the inadequacy of information on inventory of resources for emergency response, the MHA initiated the IDRN in collaboration with UNDP under the GoI-UNDP DRM programme to systematically build up the IDRN inventory as an organised information system. The online information system is hosted at the National Informatics Center (NIC), New Delhi. It can be accessed at the address http://www.idrn.gov.in. IDRN is a platform for managing the inventory of equipment, skilled human resources and critical supplies for emergency response. The primary focus is to enable the decision makers to find answers on availability of equipment and human resources, required to combat any emergency situation. The IDRN website needs to be updated regularly.

Strengthening of IDRN activity with updating of information will be carried out on a regular basis.
[Action: MHA]

7.7.4 As a unique example of public-private partnership in the field of DM, the Confederation of Indian Industry (CII) has also created a web-enabled resource inventory, consisting of large records of information

obtained from different central and state government departments, agencies and organizations, useful for emergency response in the event of any disaster, like urban flood, etc. Such activities need to be strengthened and continued.

Each ULB should involve the corporate sector in making available their services and resources for emergency response. This should form an essential part of DM plan. All available resources should be documented. The IDRN should also be used during response.

[Action: States/UTs and ULBs]

7.8 Challenges in Responding to Urban Flooding

7.8.1 People, and also agencies, responsible for management of urban flooding are generally not well prepared to deal with the emergencies. The challenges in responding are:

i) Access – Roads are flooded within the cities. Sometimes the cities/ towns get cut off due to severe flooding,

ii) Coordination between relief agencies– between different government agencies as well as between government and private agencies/NGOs,

iii) Water supply and solid waste management - When services like water supply and solid waste management are weak, they would get further drastically affected due to floods. Water Supply- first priority – drinking water – water bottles or sachets - restore water supply on war footing after the event,

iv) Lack of public awareness – people will not be prepared to deal with flood emergencies,

v) Lack of early warning capability,

vi) Lack of real-time rainfall data, and

vii) Lack of modelling for framework and impact assessment.

7.9 Challenges to Evolve Disaster Response Capability

7.9.1 One of the prime prerequisites for effective disaster response capability is to educate people about their risk and prepare warning reaction plan. It is only then that people are likely to heed and act upon warnings. Following are the response capacities:

i) Lessons learnt from past disaster response, need to be progressively incorporated into response strategies,

ii) Updating of response plans is to be a continuous process through joint participation of scientific institutions with responder/stakeholder groups, by fully accounting the requirements of the people at risk,

iii) Important consideration of disaster managers, include determining how safe and adequate public evacuation and other response facilities are, how to effectively move large numbers of affected people safely and how to maintain order and security during evacuations in an integrated manner,

   a) Special healthcare support for women (pregnant and lactating), children, senior citizens,

b) Rescue planning for low-lying areas, including night rescue operations in liaison with Fire Brigade/Fire and Rescue Services, Civil Defence Teams, Resident Welfare Associations, NDRF/SDRF, etc.

iv) Preparedness for crisis management and response with a notified calendar of planning and review meetings with all stakeholder/responder groups, including elected representatives of ULBs, etc.,

v) Random evaluation of emergency preparedness by independent groups ahead of the monsoon season,

vi) Mechanism to check/monitor and review grounded response actions and initiate corrective measures,

vii) Social audit of response actions,

viii) Awareness about regional factors of vulnerability, contributing to local urban flood risk enhancement,

ix) Organize the required tools and machinery for search and rescue operations, clearing of road blocks by fallen trees, debris, etc.,

x) Ensure the availability of necessary maintenance resources for the restoration and sustenance of essential services, and

xi) Ensure total compliance of SOPs associated with the emergency response cycle.

a) Restoration of power, telecommunications, road and railway transport will get top priority, and

b) A system to determine the safety of relief and relocation infrastructure, capacities of the emergency evacuation machinery and integrated support of emergency health care, night rescue, restoration of energy and food supply, etc., will be institutionalized.

[Action: States/UTs and ULBs]

7.10 Disaster Response Mechanism

7.10.1 Some important components of the Disaster Response Mechanism are:

i) Development of EWS, Warning Dissemination and impact assessment framework,

ii) Early evacuation, where there is sufficient lead-time,

iii) Emergency evacuation plan and inventory of vulnerable areas and hotspots,

iv) Integration of urban flood risk assessment systems with the appropriate warning and dissemination systems,

v) Identification of shelters,

vi) Generating public information tailored to target groups and making innovative use of the media and education systems,

vii) Establish local benchmarks and performance standards for warning services,

viii) Develop formal mechanism for public representatives to monitor and oversee warning systems design,

ix) Use surveys to measure public awareness and satisfaction,

x) Create documents, publications, annual events and other anchors of public memory and learning, and

xi) Conduct mock drills to assess the preparedness of all agencies and the community,

7.10.2 Timely response is extremely important. Failure/ delayed response often stems from lack of planning and coordination. This results in avoidable loss, both in terms of life and property. Lack of understanding by the local people of their risks, also contributes to this. Some of the challenges in evolving an effective response capability are designation of a nodal officer, a standing emergency and response mechanism and, involvement of different state and central agencies and experts. In any case, the nodal officer should be empowered to take decisions in an emergency to save life and property. Some major efforts required in this respect are:

i) Developing institutionalised multi-agency collaboration with clarity of roles and responsibilities (Defining SOPs at different levels),

ii) Enhancing organised public awareness and education for early warning response,

iii) Identification and disposal of dead bodies based on local/religious/ethnic requirements,

iv) Establishment of well-defined post-disaster damage and assessment of recovery needs of the affected communities and support systems,

v) Setting up of local level emergency medical response systems for the post-disaster scenario to deal with trauma and epidemic control, and

vi) Creation of trained ward-level volunteer force at the city level.

8 Capacity Development, Awareness Generation and Documentation

8.1 Overview

8.1.1 Capacity Development is a complex exercise that involves all round development of human resources and infrastructure for it to be sustained and institutionalized. It has to cover all phases of the DM continuum, including prevention, preparedness, mitigation, rescue, relief, rehabilitation, reconstruction and recovery. These efforts are going to be all the more challenging in the context of UFDM as it has just begun to come into sharp focus of all the stakeholders. It will be some time before the administration and the communities come to terms with it.

8.2 Urban Flood Education

8.2.1 The factors causing urban flooding are significantly different when compared to riverine flooding, which mostly impact rural areas. Cities and towns did not remain isolated when large tracts of rural areas got flooded but flood management strategies largely focused on covering extensive rural areas.

8.2.2 Rapid urbanisation and increasing population densities is a very recent trend is the time cycle. Factors contributing to urban flooding have also aggravated, leading to increasing urban flooding events. It has now been fully understood that the factors contributing to urban flooding are different and so also are the strategies to deal with such events.

8.2.3 Some key components enunciated in these guidelines for the management of urban flooding include extensive use of science and technology by establishing standing and supportive mechanism both at the national, state and the local levels for improved forecasting, early warning and communication. Appropriate design options for the stormwater drainage systems and better O&M actions are also a part of the strategy. Others include technically enhanced and administratively refined DRM efforts, improved response actions, massive awareness generation campaign, needed for administrative and political will to crystalise. It is a challenging task. Hence, capacity development in the context of urban flooding will have to carefully factored in these challenges initially and subsequently build upon them methodically, with regularity.

i) Disaster-related curricula have already been introduced by the Central Board of Secondary Education (CBSE) for classes VIII, IX and X. It has to be clearly brought out that urban flooding is different from riverine flood which largely affects rural areas. The MoUD, in consultation with the MHRD, will encourage the

CBSE to introduce modules of UFDM in classes XI and XII as well. MoUD in consultation with MHRD and the state governments will promote the efforts for the development of high-quality education materials, textbooks and field training. The state governments will encourage their school boards to develop similar content in their school curriculum,

ii) Such efforts will address all aspects of UFDM, in order to inculcate a culture of prevention, mitigation and preparedness as well as effective and prompt response, relief, rehabilitation and recovery. Case histories of major flood events will be used as valuable inputs in the process,

iii) MoUD will lead efforts to involve All India Council of Technical Education (AICTE), University Grants Commission (UGC), Council of Architecture (COA), Institution of Engineers (IE) and the state governments to develop suitable modules for inclusion in the curricula of architecture and engineering courses in the Indian Institutes of Technology (IITs), National Institutes of Technology (NITs) and other universities, colleges and polytechnics of engineering and architecture to equip the students with the requisite knowledge of flood-proof design and construction techniques,

iv) DM related aspects of medical education will receive detailed attention at different levels, so that graduating doctors, paramedics and emergency medical technicians are able to handle emergencies with a better understanding of the issues involved. One of the major public health concerns in management of urban flooding is the possibility of breakout of epidemics after a severe flooding event. Besides this, trauma care and emergency medical care are also very relevant,

v) The state governments will follow up these efforts with regular in-service refresher programmes at appropriate levels for upgradation of knowledge and skills, and

vi) There are some important human factors which contribute to urban flooding, namely, improper disposal of domestic, commercial and industrial solid waste and construction debris. These issues will be highlighted in curriculum developed by the states for schools. Implications of non-compliance of the techno-legal regime will also be included. Such efforts will go a long way in generating awareness from a young age and contribute to bringing about total understanding of all issues involved.

[Action: MoUD, MHRD, MoHFW and States/UTs].

8.3 Target Groups for Capacity Development

8.3.1 The target groups for capacity development will include elected representatives and government officials, concerned with the national and state level DM functions, professionals in visual and print media, urban planners, infrastructure development experts, engineers, architects and builders, NGOs, CBOs, social activists, social scientists, youth

organisations such as National Cadet Corps (NCC), National Service Scheme (NSS), Nehru Yuva Kendra Sangathan (NYKS), school teachers and school children.

8.4 Institutional Capacity Development

8.4.1 Different organizations have a role to play in capacity development. The State ATIs, NDRF and Civil Defense, for instance, will have the pivotal role in community capacity development. Different organizations have a role to play in institutional capacity development. States, with their own specialized institutions, can play important roles in the various aspects of managing different types of disasters. It is obvious, that each disaster, every thematic intervention in each phase of the DM cycle requires the type of expertise, which is normally available with multiple agencies, but 'no single agency' has all the requisite expertise and background.

8.4.2 ULB as a nodal agency should play a major role in coordinating efforts for capacity development. With reference to urban flooding, capacity development at the ULB level has to be integrated with the activities of community, civil defense teams, NGOs and NDRF. Components of multi-layer capacity development framework are i) Training; ii) Techno-legal framework; iii) Knowledge management; iv) Institutional capacities and v) Capacity analysis and assessment studies. Hence, capacity development revolves around several factors such as (a) appreciation and awareness of the causes and consequences of disasters including native wisdom, (b) acquire skills and abilities to be able to act and cooperate in times of imminent or actual mass emergencies, (c) caring for the young, pregnant women, old and the disabled.

Raising the Level of ATIs

i) Efforts should be made to raise the level of ATIs. The faculty should become the nodal point of capacity enhancement in the state, be able to design and supervise the technical capacity programme initiatives of line departments. They should evolve suitable training modules by taking specific needs of the line departments in consultation with knowledge institutes, undertake research studies, and mock drills to improve preparedness and response capacities, design and development of databases, etc. to meet the emerging needs of the ULBs,

ii) The State/UT governments should designate a nodal officer in the department of MA&UD to work in close coordination with the DM cells of ATIs on one side and the commissioners of ULB on other side, and

iii) DM Cells of ATIs are to work in close coordination with state departments of MA&UD and Commissioners of ULBs to ensure capacity development programmes.

[Action: MoUD, NIDM, ATIs and States/UTs]

8.5 Community Capacity Development

8.5.1 Based on international efforts and past experience, Community Based Disaster Management (CBDM) is found to be the best mode of developing ground level emergency

response and coping strategies (pre-disaster/ disaster/post-disaster), since communities and families are the first responders during the crisis. UNDP formulated DRM programmes to enhance the coping capacities of communities to deal with disasters. The DRM programme is a national initiative to reduce vulnerabilities of communities in some of the most hazard prone cities/towns of India (225 towns). This has largely benefited local communities to be better prepared to deal with disasters.

8.5.2 The approach of the DRM programme is to: a) focus on building community capacities, community based planning b) partnership with all stake-holders in DM like governments, professional bodies, training institutions, peoples' representatives, technical institutions, etc. and c) boost capacities at all levels with special emphasis on women to address disasters through an integrated approach for reducing vulnerabilities. Thematic focus is on education, training and capacity building for better preparedness and mitigation in terms of DRM and recovery at community, district and state level by strengthening linkages with SDMAs and DDMAs.

Suggested Actions for Strengthening CBDM Efforts

i) On the basis of the experience of the GoI–UNDP DRM Programme, a similar programme should be designed for the urban areas in a multi-hazard approach with special emphasis on urban flooding,

ii) The adoption of community-based DRM, people-centred approaches, and the integration of DRM strategies into the socio-economic development planning, are critical for effective flood management strategies, and

iii) *In situ* flood management approaches should ensure community preparedness. This includes participatory urban flood planning and management involving both local government and the community. Communities should also be empowered to develop their own hazard mapping and evacuation strategy. The critical role of NGOs in reducing community risks and vulnerabilities to disasters need to be considered.
[Action: MoUD, and States/UTs]

8.6 Mock Drills

8.6.1 The approach for conducting a mock-drill varies as per the complexity of scenario depending upon the potential hazards, response system of the institution and the target community. Therefore, to ensure proper implementation of a drill programme, roles and responsibilities of the concerned personnel, departments, corporate bodies, stakeholders, and mechanisms for conducting the drill will be delineated clearly.

8.7 Role of Civil Society

8.7.1 The NGOs have graduated from being mere relief organisations to focusing on rehabilitation, reconstruction and mitigation. They have formulated and grounded community-based indigenous coping mechanisms and developed methodologies in facilitating community-drawn comprehensive contingency plans including resource, vulnerability, social mapping, etc. NGOs have integrated disaster mitigation as a component of the development programs they have triggered. Livelihood options are being explored as an important ingredient of the

development process. Women's Self-Help Groups (SHGs), CBOs and other grassroot organisations are involved in the disaster mitigation process. Community media is being used as a tool to spread awareness. Government resources are also being tapped so as to work in coordination with them for optimum utilisation of resources. It is in this background that a strategic collaboration between the institutions of state and the institutions of civil society has to be worked out in order to facilitate better community-based disaster response in Indian cities.

Civil society needs to consider the enhancement of the socio-economic conditions of the poor, alleviate poverty and improvement of livelihood of these vulnerable groups.

[Action: States/UTs and ULBs]

8.7.2 Task Force/ Volunteer Groups

In the urban areas, the local level RWAs, covering colonies, apartments as well as SDAs, generally take an interest in various activities of the residents, including development and interaction with local authorities. They should be encouraged to form local level Task Force/ Volunteer Groups (TF/VG), who work closely with the civil defence officials. They should be trained to deal with emergencies and be generally exposed to all aspects of DM including prevention, preparedness, mitigation, rescue, relief and recovery.

8.7.3 The TF/VG should also be actively involved in awareness generation, particularly about compliance of various rules and guidelines and supervision of important works like maintenance of stormwater drainage systems including desilting in the local areas. All such people should be brought under the close coordination of the volunteer groups.

Suggestions for Establishing Effective Community Level First Responder Support

i) Encourage local residents to constitute first responder support groups consisting of ex-servicemen, retired police personnel, paramilitary forces and RWAs,

ii) The owners/those connected with management of organisation which generates bulk solid waste in commercial areas running of hospitals, hostels, community halls, hotels and restaurants,

iii) These people should be encouraged to be part of the TF/ VG,

iv) The VG can be trained by the teams of Civil Defence, SDRF, NDRF, etc.,

v) Involve various youth organisations, namely, (i) NCC, (ii) NSS, and NYKS to have the inherent advantage of outreach at the grass-root level and also have the advantage of ready availability for immediate assistance at the ground level in the event of any disaster, and

vi) Develop emergency response plans for hospitals and government offices.

[Action: States/UTs and ULBs]

8.8 Handling Societal Impacts of Urban Flooding

8.8.1 Large number of urban locations are located on hazard prone land areas and a big majority of people are affected because of flooding. Irrespective of whether urban floods are part of larger riverine floods or result from inadequate drainage capacities, the damage

potential of floods in cities is extraordinarily high. The main impacts of flooding on the population include, material damage and loss of life; the interruption of economic activity in the flooded areas; infection by water-borne diseases; and water pollution when toxic-waste dumps are flooded.

8.8.2 Given the high spatial concentration of people and values in cities, even small-scale floods may lead to considerable damage. In extreme cases urban floods can result in disasters that set back urban development by years or even decades. Recent statistics clearly indicate that economic damages caused by urban floods are rising.

8.8.3 While the number of people killed/ affected or rendered homeless and the damage to property can be quantified, these statistics, although profoundly revealing, do not include the significant indirect, and often less tangible and more difficult to quantify, associated societal impacts to individuals, families and communities.

8.8.4 Second-order impacts from disaster response actions and medical problems can occur days to weeks after the event. Third-order impacts from changes in tax revenue and land-use can occur months to years later. It is easy to identify some of these impacts, but often difficult to quantity and/or qualitatively evaluate them.

8.8.5 As the disadvantaged socio-economic groups live in the most vulnerable areas, floods usually impact very severely on the poorest in the societies. Specific strategies are required to build resilience in the most vulnerable groups. On the other hand, severe episodes of urban flooding are great levellers as the middle class and the affluent class also get severely affected.

8.8.6 In cases of extensive and protracted damage, economic damages can be extremely high. As urban centres have developed into centres of economic activity with concentrated enterprises dealing in commerce and industries like service, IT, manufacturing, banking, etc. therefore, there is also a need for a business continuity plans.

8.8.7 Increase in property damages due to urban floods have been largely attributed to increases of coastal population, increase of urban population, increase of human activities and an absence of a hedging mechanism such as insurance for life and property and risk transfer.

8.8.8 The priorities of the poor and those living in subsistence economies are sustenance of their sources of livelihood and securing food, shelter and clothing. When urban floods impact the poor, their livelihoods along with their ability to obtain food, shelter and clothing can be significantly disrupted. Coastal communities that do have the capability to feed and provide suitable drinking water to their population can lose this basic capability following urban flooding. This may have disastrous short-term and long-term effects. Where the ability of communities to withstand and recover from natural disasters is diminished, the application of social protection programs and policies is required to reduce people's exposure to risks, enhancing their capacity to protect themselves and thus reduce the population's vulnerability.

Suitable hedging mechanism like insurance of life and property need to be evolved to reduce urban flood vulnerability.

[Action: MoUD and States/UTs]

8.8.9 Knowledge integration, management and dissemination are critical components of the technical capacity development to be accomplished by building partnerships and developing networks with all knowledge and S&T institutions on a continuous basis.

The main issues, related to institutionalizing capacity enhancement are:

Table 8.1: Interventions for Capacity Development

Groups have to be trained	Scope	Responsibility
IAS/IPS, Officials at Central & State level & those connected with Ministries/ Departments like Urban Development, Railways, Roads, Power, Health, Transport, Airports, Irrigation, PWD & DM, IMD/ CWC	Urban Flooding issues	• Lal Bahadur Shastri National Academy of Administration, Mussourie • NISA, Police Training Academies, ATIs • NIC & academics in states • NIDM
Officials of ULBs, States and UTs dealing with Town Planning, Engineering, Sanitation, Water Supply & Sewerage	Municipal Solid Waste disposal, designing & management of Stormwater Drainage Systems, Techno-Legal Regime, Early Warning Systems, Response and Awareness Generation	• Professional bodies and Councils in states • State ATIs (in consultation with IITs and NITs) • NIDM
Health Professionals	Crisis management, emergency medical response/recovery and trauma management	Ministry of Health & Family Welfare & ATIs
SRSAC	Urban Flooding issues	NIDM, ATIs, NRSC
NGOs/ RWAs Youth organisations (NCC, NYKS, Scouts and Guides and NSS)	• Developing network of NGOs at state and district level in an hierarchical manner for multi-layered capacity enhancements by integrating govt. efforts	NIDM SDMAs, ATIs and ULBs NDRF and Ministry of Sports and Youth Affairs, Ministry of Defence, States and ULBs

	• Co-opting NGOs in the evolution of local developmental planning and response mechanisms at all levels • Awareness Generation, Disaster Preparedness, Mitigation and Planning • Disaster response, search and rescue in their orientation capsules	
Mass media campaign for awareness raising through Print & Electronic Media	• Design and develop a region-specific communication strategies • Use visual and print media • Development of modules on mitigation, preparedness and response	Local Bodies, ATIs
Corporate Sector	Planning and execution of Emergency Response Actions & Business Continuity Plans	NDMA, SDMAs, FICCI, CII, ASSOCHAM, NASSCOM, etc.

i) Networking of academic researchers with stakeholders in the government and the community for enabling appropriate awareness campaigns, and

ii) Creating a repository and flood-specific information database for multi-sector risk mitigation efforts and carrying out capacity analysis based on international best practices.

Lack of technical capacity enhancement of domain-specific skills can severely paralyse the DM infrastructure and administrative mechanisms. Design and development of relevant educational and communication campaigns and launching them from time to time is important.

[Action: NIDM and ATIs]

8.9 Objectives of Awareness Generation

8.9.1 Objectives

8.9.1.1 Urban floods have the greatest damage potential of all natural disasters worldwide and affect the greatest number of people. On a global basis, there is evidence that the economic damages resulting from flooding are on the rise at an alarming rate. There is a need for large scale awareness as a program integrated at all levels of stakeholders.

8.9.1.2 In the context of DM, awareness generation should have two objectives. First, it will prepare communities to deal with disasters in a manner that people's lives and properties are protected, and to ultimately become resilient.

8.9.1.3 Public awareness generation will serve to empower people with knowledge about the role and responsibilities of the state, leading to crystallisation of political and administrative will. This will manifest itself in better and timely strategies for disaster risk reduction.

8.9.1.4 A holistic plan of action encompasses enrichment through interaction on an international scale of insights, experiences and innovations. There is a diverse range of urban flood disaster situations that India experiences with complex socio-economic and habitation patterns specially associated with rapid urbanisation manifesting itself both in higher density of population and geographical spread. Such a holistic perspective helps to develop an integrated framework of (a) capacity analysis and (b) community preparedness. It is noteworthy that a rich variety of awareness initiatives have already been set in motion by a network of institutions in India at the national, state and local levels, both in the private and public sectors. MCGM and NGOs of Mumbai have taken a number of initiatives which can be built upon.

8.10 Target Groups

8.10.1.1 Awareness generation should reach out to different target groups at the household, community and institutional levels, so that all the stakeholders can be expected to play their own part in dealing with all aspects of urban flooding.

8.10.1.2 As discussed in National Guidelines on Management of Floods, the most basic thing is that the community is to be aware of vulnerability which can vary from low to very high, but keeping the mobility of the people in the urban areas. They have to sensitise in all situations. Very often people are not aware of how individual actions can contribute to betterment or deterioration of vulnerability. So, any awareness generation should aim to highlight all such issues. Awareness generation should look at target audience at household, community and institutions.

8.10.1.3 All these target audiences have to continuously interact and coordinate according to the community level preparedness and emergency response plans. Expected levels of awareness about flood risk should include information about vulnerability of different areas to flooding, its impact and a checklist of preparedness and mitigation measures. Focusing on skill development through ground-level disaster preparedness programmes across the target audience groups is very important.

8.10.1.4 There are certain mental psychological barriers of individuals at all levels to be addressed by the local authorities and community awareness groups. This includes feeling of helplessness in the disaster affected areas and complacency in other areas. Considering another factor is lack of ownership, i.e., the problem of local authority and not their problem. Additional factors are loss of land, loss of income, insecurity of women and children in relief centres and poor arrangements for food and sanitation there.

8.10.1.5 Urban flood risk mitigation demands a close and simultaneous coordination among the target audience at different levels.

8.11 Household Level

8.11.1 Awareness generation at the household level plays a crucial role in building a sense of preparedness amongst them. Special efforts should be made to reach out to women, children and differently-abled. Even though the school going children can be targeted at the institutional level but there are many children, especially among the most vulnerable groups belonging to

the marginalised sections of the society who are deprived of formal school education.

8.11.2 In the event of an impending disaster, they should be aware of all actions that need to be taken to protect themselves, their property and valuables even in the absence of the head of the family.

Awareness at Household Level

Family should be encouraged to prepare a flood check list that will cover the following:

i) Include a list of telephone numbers for family, friends and community leaders,

ii) Prepare a safety kit which should include a torch, sheets/ blankets, waterproof clothing, battery-operated radio, bottled water, first-aid kit, medication, personal valuables and personal documentation,

iii) Store valuable, sentimental items and important documents upstairs or in a high place,

iv) The role of community leaders in evacuation and moving to safe places, and

v) A massive awareness campaign has to be launched on proper disposal of solid waste, desilting of drains and water bodies and prevention of encroachment on to flood plain, taking into account its serious impact and extremely low level of public awareness.

8.12 Community level

8.12.1 At the community level the RWAs/ SDAs, Basti Committees, SHGs, youth clubs and other social-cultural organisations and NGOs have a major role in all other DM actions.

8.12.2 Capacity building will cover response related to pre- and post event actions i.e., search and rescue, emergency medical preparedness, flood shelter and relief camp management, incident response systems (IRS), special dispensation for vulnerable groups, participatory damage assessment, etc.

8.12.3 Besides, it should also cover actions relating to preparedness like formation of local TF/VG, drawing up micro-plans and various other preparedness, mitigation, design and management aspects.

8.12.4 Standard platforms for convergence at the local level would need to be created with NGOs, and other stakeholders. A humanitarian and rights based approach will permeate the dispensations and provisions made for the affected people. Other social mandates like revenue, water and sewerage board, public distribution, social justice and empowerment to orient them regarding their collective responsibilities in DM.

8.12.5 RWAs, elected periodically and periodically represent various issues of welfare of the members. It should be ensured that such RWAs are formed in all the wards and possibly in larger colonies, a federation of the RWAs should also be encouraged. The RWAs are to be totally sensitized about all aspects of urban flooding on a regular basis. They should also be involved in the supervision of desilting carried out by the ULBs. A system of incentive should also be devised to enlist their support in a proactive manner in dealing with the issues of solid waste and debris.

8.13 Institutional Level

8.13.1 Awareness generation programmes should target both students and staff of educational institutions like schools, colleges, universities and officials at various levels of the ULBs and NDRF/SDRF.

8.13.2 Awareness generation on disasters can be done through a structured syllabus approach, play settings, mock drills and simulation exercises. The need for appropriate eco-friendly environment initiatives especially solid waste disposal needs to be highlighted.

8.13.3 Familiarization with the meteorological aspects of flood, early warning and communication in an appropriate user friendly manner.

8.13.4 Historical knowledge of past disasters and traditional coping skills.

8.13.5 The ULBs should take up measures for display of high water marks of the historic floods and also place sign posts like, Flood Prone Areas, "Turn Around, Don't Drown", at crossing points, etc. and at all vulnerable places.

i) Public awareness will be created about the need to keep safety kits containing medicines, torch, identity cards, ration card, important documents and non-perishable eatables such as dry fruits, roasted channa, etc. ready before commencement of monsoon so that, they can carry the same with them, in case they have to be evacuated,

ii) The community will also be trained for preparation and utilisation of improvised flood rescue devices with household articles, and

iii) Specially designed public awareness programmes will be developed for addressing the needs of physically handicapped and mentally challenged people, women and the elderly. The State Police Force, Civil Defence, Home Guards and SDRFs will also be covered by such efforts.

[Action: NDRF, States/UTs and ULBs]

8.14 Role of Public Representatives

8.14.1 The role of public representatives becomes critical in dealing with all UFDM issues. Therefore, public representatives have to be sensitized on all the factors, related to urban floods and made responsible to play a major role in generating public awareness for UFDM.

8.14.2 Elections are held once in five years and whenever there is a new body of elected public representatives right from Parliament to the ULB level should be sensitized to at the beginning of their tenure. This will greatly facilitate their active cooperation in all matters related to Urban Flood Disaster Reduction.

Public representatives including Municipal Ward Members, MLAs and MPs are regularly elected by the people, directly or indirectly. They have a very close contact with the people at the grass-root level and their cooperation will be enlisted for various awareness generation programmes on a regular basis.

[Action: States/UTs and ULBs]

8.15 Role of Media

8.15.1 Media has a major role in generating public awareness. Media persons should first be sensitised about all aspects of UFDM and therefore appropriate training modules should be prepared for them. It is only after all important aspects of urban flooding are clearly understood by them, that they can put things across to the people with a proper perspective.

Key considerations for an effective visual media awareness campaign are:

i) All TV channels and local cable networks will be covered,

ii) Have a sequence of episodes, depicting a story on flood awareness,

iii) Slot during the highest viewership programmes like films/popular TV programmes, local cable networks,

iv) Create a strong emotional flavour of local linkage in the documentary, and

v) The theme will be based on the case study of a few bravery stories, related to floods.

Key considerations for an effective radio-based awareness campaign are:

i) The frequency of airing the warning will be half the number of news programmes aired every day,

ii) Design quiz questions related to flood awareness,

iii) Arrange toll free numbers for facilitating live participation/interaction by the target audience groups, and

iv) Identify the standardised case study templates for ease in capturing such real-life events.

Other possible awareness options that are to be employed for effective local level urban flood risk awareness campaigns include:

i) Electronic Display Boards,

ii) Skill-based competition programmes in schools/public gatherings/group discussions,

iii) Mock drills and simulation exercises,

iv) Pamphlets, brochures and handouts,

v) Song and Drama division of Prasar Bharati for street plays, etc.,

vi) Exhibition on flood themes, and

vii) Mapping and transfer of best practices: newsletter based on risk mapping of wards, along with periodic feedback as per the pre-determined format.

i) Steps will be taken to evolve appropriate media campaign covering radio, visual and print media besides the production of printed materials like brochures, pamphlets, posters, etc., and

ii) Media companies will also be motivated to launch/expand awareness generation programmes as a part of their CSR.

[Action: States/UTs and ULBs]

8.16 Linking Awareness to Techno-Legal Regime

8.16.1 Techno-legal regime has been discussed in chapter 6. Generating awareness on the need for strengthening techno-legal network is very important and it should be given a high priority. This is true at the household, community as well as institutional level. At the institutional level, architects, town planning officers, RWAs should be the special target groups. A clear provision should be made for dumping of debris and solid waste as a part of development of new urban areas. They also identify with existing areas.

8.17 Awareness on Insurance

8.17.1 Insurance and risk transfer has been discussed in chapter 5. All sections of people, particularly the poorer sections and lower-middle classes, suffer from losses to property. Appropriate insurance cover will help them to recover, at least, part of the losses. Awareness generation programme should include modules

to educate people on the benefits of insurance coverage. This should be done with active cooperation from the insurance companies.

Awareness generation campaigns should be initiated by states/UTs, ULBs and other stakeholders. State governments, local authorities and other stakeholders are to communicate the benefits of insurance. This should be done with active cooperation from the insurance companies. MoUD should coordinate efforts for this.

[Action: MoUD, States/UTs and ULBs]

8.18 Documentation

"It hardly needs to be said that organizations cannot learn from failures if people do not discuss and analyse them. Yet this remains an important insight. The learning that is potentially available may not be realized unless thoughtful analysis and discussion of failure occurs"

Amy Edmondson and Mark D. Cannon, Harvard Business School Paper, *The Hard Work of Failure Analysis*, August 22, 2005

8.18.1 Every disaster event throws up some "success" stories. Then there are some instances of "consequences of inaction". There are also some glaring "failure" stories.

8.18.2 While most of the time the "success" stories get well documented, "consequences of inaction" and "failure" stories tend to be ignored or even covered up. "Success" stories can serve as an inspiration and must be used in awareness generation campaigns. But the importance of the other two categories will not be undermined.

8.18.3 A lot has to be learnt from failure investigation, it needs to be converted as an opportunity to learn to ensure that such things are not repeated in future.

8.18.4 Faithful and accurate documentation of all aspects of disaster events is essential for creating good historical records that finally became the data source for future research and mitigation planning. In the past, some good efforts had been made by some of the scientific departments like IMD and administrative departments in the centre and states as well as individuals. Recently, some technical groups, DM institutes as well as NGOs have also joined hands in documenting the disaster events in the country.

8.18.5 Mostly, these are sectoral reports and a comprehensive document taking all facts and figures (scientific, technical, loss and damage and economical) into consideration are not available. Sometimes data presented on an individual item widely differs from report to report. To reduce/minimize such deficiencies, following remedial measures are recommended:

i) Post-event survey will be carried out by a "Pre-designated team" including experts and officials from concerned scientific, technical, administrative departments and NGOs immediately after it occurs.

ii) Formats of data collection will be pre-designed for every department /group, so that error is minimal.

iii) A comprehensive document will be prepared involving all the stakeholders.

i) Documentation shall cover all aspects of early warning, communication, design and maintenance, successful actions/ failures and the results thereof, covering search and rescue, evacuation, management of flood shelters, food and water supply, restoration of essential services, public health issues, management of traffic and all other activities, and

ii) NIDM/ATIs will prepare a standard format for all classes of cities/ towns.

[Action: NIDM, States/UTs and ATIs]

8.19 International Experiences

United Kingdom

According to Sir Michael Pitt, who undertook a comprehensive review - the UK Floods Review, 2008, the floods that struck much of the country during June and July 2007 were extreme affecting hundreds of thousands of people. The rainfall during June and July that year was unprecedented. It was the wettest May to July period since records began in 1766. The total cumulative rainfall in those three months averaged 395.1 mm across England, which was over double the usual levels. The annual average rainfall in that year was 934.5 mm as against the normal of 838 mm. It is estimated that annual losses are 270 million pounds sterling in England and Wales with 80,000 homes at risk. Its impacts are expected to increase if policy changes are not made and implemented without any delay.

Urban flooding is also expected to happen more often in UK. It is projected that the cost of urban flooding in U.K. could rise to between 1-10 billion pounds sterling annually by the year 2080 if policy changes are not made and implemented and mitigation measures taken to reduce the risk.

Brazil

Torrential rains hitting Rio de Janeiro in 2010, resulted in the worst floods in last 40 years. Flooding and mudslides killed more than 153 people. Flooding was so severe that about 1.5 million people i.e. one-fourth of the population had been affected, and nearly 79,000 residents had been left homeless.

Argentina

Argentina is having highest concentrations of urban population with approximately 90% of people residing in urban areas, which very often witness flooding with serious consequences. In recent decades, Buenos Aires has experienced frequent flooding, resulting in serious problems and considerable material damage due to constant, unplanned growth of the city, the lack of investments and the change in the precipitation pattern.

Tanzania

Climate change is making the weather less predictable, rains more uncertain and heavy storm rainfall more likely. The unpredictability of rainfall is evident from large fluctuations in the levels of Lake Victoria in Africa since 1980 and by the experience of long-term urban slum residents who report more frequent storms, producing floods since 1990. Heavy thunderstorms appear to have increased in frequency.

Nigeria

Flooding has become more frequent, affecting residents of the low-lying coastal slum settlements of Iwaya/ Makoko in Lagos, Nigeria. Homes were built on stilts above swamps that

are natural floodplains but increasing peak flows, combined with higher spring tides, are affecting more homes more than before.

Asian Experiences

Dhaka

Dhaka, the capital city of Bangladesh covers an area of 275 sq km and has population of more than 7 million with a population density of 23029 per sq km. The city is situated on the banks of the river Buriganga and surrounded by the distributaries of the two major rivers, the Brahmaputra and the Meghna. The elevation of the city is 2 to 13 meters above the mean sea level.

Dhaka city has been experiencing floods on a regular basis and sometimes even moderate rainfall overwhelms the drainage system of the city. In September 1996, Dhaka experienced local heavy rainfall resulting in severe waterlogging. A flood modeling study was initiated with a combined approach of physically based modeling and GIS for simulating the free-surface flow over the streets and the sewer pipe system for a detailed representation of the real-life situation. Surface Water Modeling Centre, Dhaka carried out another study in 1997, for modelling on Stormwater Drainage in the City as an extension and improvement of pilot study in terms of updating and analysing drainage system.

Dhaka also experienced heavy flooding in 1998 because of heavy local rainfall. The impact of flood was so severe that it damaged more than 262,000 shelter units and the loss was Tk. 2,311 (approximately, USD 33.23 million). The causes are hydraulic leakage, failure to operate the regulators, and lack of timely pumping of accumulated water upstream. Unplanned and uncontrolled expansion of the city stretching rapidly towards the low-lying areas and floodplains adjacent to the flood protection embankment and rivers are also increasing the vulnerability.

Bangkok

The Bangkok Metropolitan Area covers an area of 7,761.50 sq km and has an approximate population of 11,971,000, with a population density of 1,301.42 per sq km. The elevation of the city is 0-2.5 m above the mean sea level. It is situated in Chao Phraya River Basin. In view of this, the metropolitan authority initiated efforts to mitigate flood damage in the river basin through the construction of dams, reservoirs, dykes and pump stations.

A disastrous flood occurred in 1995 which resulted in extensive damage to properties and loss of human lives. The economic losses were calculated as Baht 72 billion (approximately, US$ 2.34 billion). Again, a much worse monsoon flood was experienced in 2006. High tides have also contributed to its severity.

The Bangkok Metropolitan Authority has carried out a model study in 2002 on a pilot basis covering approximately 25 sq km. The modelling simulates the flow in the sewer, the drainage system and the surface flow to manage and mitigate flooding and associated damage.

Hong Kong

Hong Kong city covers an area of 1104 sq km and has an approximate population of 6,708,389 with a population density of 6076.4 per sq km. The city is situated near to the mouth of the Pearl River estuary. The city is surrounded by the South China Sea on three sides and borders the Guangdong city to Shenzhen to the north over the Shenzhen River.

Vulnerable to 'typhoons' (cyclones), Hong Kong city is often flooded with relatively high rainfall. The city experienced highest rainfall in 124 years recorded as 145.5 mm in 1hour on June 7, 2008. The old drainage system for protection of flood management is becoming inadequate due to aging of the system and expansion of the built-up area. The city administration has adopted flood prevention and management strategies by upgrading of existing system, flood storage, pumping and tunneling.

Jakarta

Jakarta, the capital city of Indonesia, covers an area of 661 sq km and has population of 8,792,000 with a population density of 12,957.31 per sq km. Jakarta is a coastal city situated at the mouth of the Ciliwung River. The river divides the city into the western and eastern principalities. The city lies on a low, flat basin, averaging 7 meters above sea level and northern areas of the city is below sea level.

Jakarta experienced serious flooding in 1996 and 2002 which resulted in the death of 10 and 25 people respectively. The 2007 Jakarta flood is considered to be the worst ever incident of flooding. About 80 people were killed and over 70,000 homes were affected, resulting in the displacement of 200,000 people. About 190,000 people had fallen ill due to flood-related illnesses. The 2007 flood occurred due to heavy rainfall in upstream area.

Subsequent to the 2007 floods, a FHM framework was carried out. The framework consists of 3 modules i.e., rainfall-runoff, hydraulics and inundation calculation.

Kuala Lumpur

Kuala Lumpur, the capital city of Malaysia, covers an area of 244 sq km and has population of 1,809,699 with a population density of 7,388 per sq km. The city is situated in a huge valley known as Klang Valley and located at the confluence of the Klang and Gombak rivers. The elevation is 21.95 m above the mean-sea level.

The major flash floods disaster in 1971 was a result of heavy monsoon rains. A total of 32 people were killed and 180,000 people were affected. The flood was the worst in the country since 1926. As a result of the flooding, total loss was more than RM 200 million (approximately, USD 64.63 million). They took up a flood modelling study in 2007 for simulating the system of hydrodynamics. The model simulates the flow in the Klang River and tributaries and the overtopping of flow onto the streets of Kuala Lumpur.

Seoul

Seoul, the capital city of South Korea, covers an area of 605.52 sq km and has population of 10,321,449 with a population density of 17,046 per sq km. Seoul is surrounded by eight mountains as well as a very important river named as Hangang River.

Widespread flooding in Seoul in 1998, caused by torrential rain was the worst flooding in 80 years. A storm deluged the metropolitan area of Seoul with 620 mm of rain, making it one of the heaviest downpours on record. The resulting floods and mudslides killed 131 people, left 61 missing and caused damage estimated at US$ 323 million. The administration initiated the study to control the runoff through the Rainfall-Storage-Drain models. The model is developed for the design of rainwater tanks for flood control. The design was made to study the distribution and runoff analysis on rooftops for analysis of the rainfall process.

8.20 Indian Experiences

8.20.1 Most cities in India that get flooded have experienced loss of lives and damage of property, disruptions of power, transport and communications and incidences of epidemics during the monsoons. Most notable amongst them are Mumbai in 2005, Surat in 2006, Kolkata in 2007, Jamshedpur in 2008, Delhi in 2009, Delhi and Ahmedabad in 2010. Most of these cities are major economic centres with a large number of international business operations, which were severely affected when they got flooded. The annual losses from urban flooding are now much greater than the annual economic losses due to other disasters.

Significant Urban flooding events in India since 2000

2000 – Mumbai, Chennai, Bangalore, Kolkata, Hyderabad

2001 – Ahmedabad, Bhubaneswar, Thane, Mumbai

2002 – Delhi

2003 – Delhi, Ahmedabad, Vadodara

2004 – Chennai

2005 – About 10 cities; Mumbai was the worst affected.

2006 – Number of affected cities rose to 22. Surat was the worst affected. Vishakhapattanam airport was inundated for more than 10 days.

2007 – Number of affected cities rose to 35. Kolkata was the worst affected.

2008 – Jamshedpur, Mumbai, Hyderabad were worst affected.

2009 – Delhi, Mumbai

2010 – Delhi, Guwahati, Ahmedabad, Leh, Mumbai

Mumbai

Mumbai experiences severe flooding every year that causes serious disruption to the activities in the city. This may be attributed to Mumbai's topography which has been formed with a merger of seven islands with the main island of Salsette, together forming the area under the MCGM and the fact that Mumbai receives an average annual rainfall of 2401 mm, all of which comes during the monsoon months from June to September.

The city has an area of about 437 km with a population of 17.7 million (2001). On 26th July 2005, Mumbai came to a complete halt due to the unprecedented rainfall of 944 mm in 24 hours, starting 0830 on 26 July 2005 with 875 mm occurring in the 12 hours from 1430 to 0230, which resulted in colossal damage to the city with loss of at least 479 lives. The century old drainage network of Mumbai had been designed to carry only 25 mm of rainwater per hour while the drainage in the suburbs is mostly through the open stormwater drains. With drains clogged at several places, it proved totally inadequate for the 944 mm rain which lashed Mumbai that day.

Following this, the Chitale Committee was set up to review the reasons for the flooding and make recommendations. The overflow of Mithi River and obstructions in its floodplains were identified as the major man-made cause for the flooding. Presently, the Brihanmumbai Stormwater Drainage Project is being redesigned for 50 mm/h rainfall and is expected to be completed by 2012. They now have a very good city DM Plan in place.

A rapid flood risk assessment (FRA) for Mumbai - "Rapid Assessment Flood Inundation Mapping" is being carried out by the

Indian Institute of Technology (IIT), Bombay in association with MCGM.

Surat

Surat is located on the banks of the River Tapi, and faced its worst flooding in 2006, due to heavy rainfall and sudden release of water from the Ukai Dam. The city area is 112 sq km with a population of 6.5 lakhs (2001). Surat is the centre of diamond processing in India. The average annual rainfall in Surat city is 1894 mm. Under the JNNURM, various strategies such as drainage rehabilitation, construction of roadside drains, rapid implementation of flood protection scheme and desilting of the River Tapi and open roadside drains have been formulated for improving the drainage system of the city by 2012. They also now have a very good city DM Plan in place.

Ahmedabad

Ahmedabad city covers an area of 190 sq km with a population is 4.5 million (2001). The city is located on the banks of the River Sabarmati and the average annual rainfall in Ahmedabad is 782 mm. However, rainfall of 508 mm in 13 hrs flooded all the low-lying areas of the city in 2001. Besides torrential rain, release of water from Dharoi dam located upstream on the River Sabarmati in 2005, caused severe disruption to the city. The drainage system of the city was designed in the past for a rainfall intensity of about 12.5 mm per hour.

Delhi

Delhi is the capital of India with an area of 1483 sq km and the population of Delhi (including New Delhi) is 13.8 million (2001 census). It is located on the banks of the River Yamuna and the average annual rainfall is 711 mm, most of which falls during the monsoon in June to September. It is administered by the Municipal Corporation of Delhi and the New Delhi Municipal Council (NDMC). Delhi experienced its worst flood in 1978 when water level reached at 207.49 m (danger level in Yamuna river is 204.83 m) with discharge of 2.53 lakh cusec at old railway bridge (7.0 lakh cusec was released from Tajewala upstream). It had also suffered floods in 1924, 1947, 1967, 1971, 1975, 1976, 1988, 1993, 1995, 1998 in the past.

In 2009, the Lodi Road Observatory recorded a rainfall of 137 mm in 24 hr by 8.30 am on 27 July 2009. It resulted in severe flooding. More than half of this rain was realized in two hours - from 2000 to 2200 hours in the previous evening.

During the month of September 2010, Delhi had already experienced three major spells of flood till 21st September in the river Yamuna, which inundated many areas of Delhi and this is unprecedented in recent times. By 21st September, Delhi had recorded seasonal rainfall of 974.2 mm, already exceeding the previous record of 965.7 mm received during entire monsoon season of 1978. In addition to the local rainfall, the upper catchment of the Yamuna basin also received very heavy rainfall and this resulted in repeated flowing of large quantities of water from Hathinikund Barrage.

Kolkata

Kolkata is the capital city of West Bengal. It is located on the banks of the River Hooghly. The Kolkatta Metropolitan Authority (KMDA) area is 1851 sq km with a population of 14.72 million (2001 census) out of which 271 sq km is administered by the three municipal corporations of Kolkata, Howrah and Chandannagore. The average rainfall of

the city is 1640 mm. The city received a record rainfall of 369.6 mm on 28th September 1978 in association with a deep depression. During 27th to 29th September 1978, Kolkata received about 720 mm of rain causing total deluge in the city for several days. This still remains a record for the city.

Kolkata faced severe flooding from 3-5 July 2007. The city received more than 300 mm of rain in first two days, which increased to 410 mm by third day. This was caused by a depression in the sea, 150 km south-east of Kolkata. Flooding was aggravated due to tidal surges, which occurred during the full moon.

Guwahati

Guwahati is the capital of Assam and is located on the banks of the Brahmaputra. Guwahati Metropolitan area covers 240 sq km with a population of 0.9 million (2001 census). The average annual rainfall in the city is 1716 mm and about 624 mm falls during July and August. Guwahati faced severe flooding in June 2010 due to the runoff from the surrounding hills flowing through the recently urbanised parts of the city.

Chennai

Chennai, the capital of Tamil Nadu, is a coastal city and has two rivers - Cooum and Adyar passing through the city limits. There are 5 other waterways including the Buckhingam Canal, which also drain the city. Chennai Metropolitan Area (CMA) covers 1189 sq km with a population of 7.5 million while Chennai City covers an area of 176 sq km. Tamil Nadu state is different from rest of India in the sense that it receives rainfall from both south-west and north-east monsoons during June to December and the average annual rainfall in Chennai is 1200 mm (750 mm during June to September and 450 mm during October to December). Major flooding events in Chennai City have been recorded during 1943, 1976, 1985, 1996 and 2005. The 2005 flood on October 26-27 occurred when Chennai received almost 400 mm rainfall and 50,000 people had to be evacuated.

An Early Warning System for Urban Flood Management is being developed for Chennai by Centre for Remote Sensing, Anna University in association with the Government of Tamil Nadu

Hyderabad

Hyderabad is the capital of Andhra Pradesh and is located on the banks of the Musi River in the Krishna Basin. The city also has the Hussain Sagar Lake in the centre of the city. The GHMC covers an area of 778 sq km with a population of 5.7 million as per 2001 census. The average annual rainfall is 805 mm of which an average of 613 mm occurs during the southwest monsoon during June to September. Analysis of recent rainfall data has indicated that the average annual rainfall has increased from 806 mm in 1988 to 840 mm in 2002. The city drainage system was designed previously for a rainfall intensity of 12mm/ hr. Instances of urban flooding in Hyderabad were experienced in the years of 1908, 1930, 1954, 1962, 1970 and 2000.

In 1908 there was a severe flood in Musi River with 12304 cusecs causing havoc in Hyderabad. There was a rainfall of 325 mm in a duration of 24 hours. In August 2000, Hyderabad received 240 mm of rainfall in a 24 hr period which resulted in very severe flooding. A study was commissioned to make recommendations for the improvement of stormwater drainage system.

A pilot project on Urban Flood Impact Assessment for Hyderabad is being taken

up by the Government of Andhra Pradesh in association with NDMA and GHMC.

2009 Krishna River Flood in Andhra Pradesh

The 2009 Krishna River Floods in Andhra Pradesh were, perhaps, the worst ever experienced. Apart from extensive flooding in rural areas, urban centres like Mahabubnagar, Kurnool and Nandyal were very badly affected, besides, Vijayawada and Repalle towns were under grave threat. It was an instance of different scenarios of urban flooding caused by a combination of high intensity local rainfall, flooding of rivers, effects of backwater and release of water from dams located downstream and upstream of cities/towns.

Mahabubnagar and Kurnool districts, which are part of Krishna River Catchment upstream of Srisailam dam, received very heavy rainfall between 29 September and 3 October 2009, ranging from 100 mm to 580 mm in Mahabubnagar district and 60 mm to 530 mm in Kurnool district. 34 out of 64 Mandals in Mahabubnagar District and 19 out of 54 Mandals in Kurnool District received total rainfall of 300 mm and more during this period (annual average rainfall in Mahabubnagar and Kurnool are 850 mm and 630 mm respectively). All this contributed to the inflows in a very significant manner.

This was compounded by rainfall ranging from 200 mm to 403 mm in the northern reaches of Karnataka forming the upper catchment of Krishna and Thungabhadra Rivers, exceeded the normal rainfall by 400% to 924%. The weighted average rainfall of 270 mm over an area of 82,000 sq km has generated over land flows approximately 10 times the discharges released from the reservoirs. The huge overland flows drained the agriculture lands, streams, rivulets and the major river courses and none of the dams like Almatti, Narayanapur, Thungabhadra could contain the huge volume. This compounded the impact in Andhra Pradesh. Bijapur, Gulbarga and Raichur towns in Karnataka were the worst affected.

There are three structures on Krishna River namely Srisailam Dam, Nagarjuna Sagar Dam and Prakasam Barrage. Peak inflows to Srisailam Dam started from 30 September 2009. The inflow touched 25.40 Lakh Cusecs on 2 October 2009 and continued at same level for more than 10 hours. It was designed for 13.60 Lakh Cusecs while the Probable Maximum Flood (PMF) for Srisailam reservoir is 26 lakh cusecs. Thus the inflow received on 2 October 2009 night almost touched this figure (which may happen once in 10,000 years).

It crossed the Full Reservoir Level (FRL) of 885.00 feet at 5.00 pm on 2 October, the Maximum Water Level (MWL) of 892.00 feet at 3.00 AM on 3 October and touched the peak level of 896.50 feet at 11.00 AM on 3 October, which continued till 6.00 AM on 4 October.

The unprecedented flood in Kurnool town was experienced due to local rainfall, floods in Tungabhadra and Hundri River (tributaries of Krishna River) besides the backwaters from Srisailam Dam. Silt was found deposited even on the third floor of buildings in some parts of the town. Nandyal town in Kurnool district got affected due to high intensity local rainfall, release of water from Srisailam Dam and flood in Kundu River. Mahabubnagar town was affected due to high intensity local rainfall. Besides these, floods in downstream of Nagarjuna Sagar Reservoir and Prakasam Barrage affected the towns of Vijayawada, Repalle and others on

the banks of Krishna River. It was also observed that the discharge of water from the reservoirs was impeded by the high tide, which further complicated the situation.

There were serious apprehensions of dam burst and damage to all these structures but the crisis was extremely well managed by the state government and release of water was very carefully regulated. With the availability of inundation maps using GIS technologies provided by Andhra Pradesh State Remote Sensing Application Centre, about 5.33 lakhs people were evacuated to safer places from both urban and rural areas. Consequently, the death toll was comparatively low at 90.

Leh

Leh is a category III city in Jammu and Kashmir with a population of 28,639. The city is a cold desert with the average rainfall for the month of August being 15.4 mm only while the average annual rainfall is 102 mm. Leh is the largest town in Ladakh region and it is located on the Ladakh plateau at a height of about 3,500 on above mean sea level. Leh town is 434 km from Srinagar and 474 km from Manali. The total population of Leh district is 1.17 lakh.

A cloudburst occurred around 0130-0200 IST on 6th August 2010. This led to a flash flood and mudslide over the region, resulting in the death of at least 172 people, with thousands injured and about 500 reported missing. Thousands were rendered homeless, with many of them losing everything under a devastating wave of mud. The village of Choglamsar on the outskirts of the city was particularly badly hit. Many buildings were destroyed, including hospitals, bus terminals, radio station transmitter, telephone exchange and mobile-phone towers. The local bus station was damaged and some of the buses were carried more than a mile by the mud. The city's airport was also damaged but it was repaired soon and relief flights were restored the following day. It was estimated that about 80% of Ladakh's infrastructure was partially damaged or totally destroyed.

Satellite images indicated that intense convective systems had developed and the cloudburst was highly localised. Although there was no rainfall record at Choglamsar, the nearby IAF observatory recorded only 12.8 mm rainfall. In the past there have been instances of cloudburst resulting in an extremely heavy rainfall of 205.74 mm in 20 minutes in Romania in July 1947 and 38.1 mm in one minute in Himachal Pradesh, India in November 1970. Looking at the damage caused in Leh, it would have been, undoubtedly, a cloudburst resulting in a very high intensity rainfall.

9 Implementation of the Guidelines: Preparation of DM Plans

9.1 Overview

9.1.1 The urban flooding DM approach aims at institutionalising the implementation of initiatives and activities, covering all components of the DM cycle, including prevention, preparedness, mitigation, relief, rehabilitation and recovery, with a view to developing communities that are well-informed, resilient and prepared to face emergencies with minimal loss of life and property. Therefore, it will be the endeavour of the Central and State governments and the ULBs to ensure implementation of these Guidelines.

9.1.2 For efficient and coordinated management of urban flooding, it is vital to evolve appropriate DM plans at the national, state and ULB levels. It is equally important to identify various stakeholders/ agencies, along with their responsibilities, institutionalise programmes and activities at the ministry/ department levels, increase inter-ministerial and inter-agency coordination and networking, as well as rationalise and augment the existing regulatory framework and infrastructure.

9.1.3 The preparation and planning for responding to urban flooding emergency is to be structured into a coherent and interlocking system. In order to optimise the use of resources and their effective response, the emergency response action plan will include well-coordinated and consolidated responsibilities, shared jointly by all stakeholders. Implementation of the Guidelines will begin with formulating a DM plan and an enabling phase to build the necessary capacity, taking into consideration the existing elements such as legislations, emergency plans, stakeholder initiatives, gaps, priorities, needs and the context. To start with, the existing DM plans at various levels, wherever existing, will be revamped/ refined further to address both immediate and long-term needs.

9.2 Mainstreaming DM into Development

9.2.1 NDMA will ensure mainstreaming of disaster risk reduction in developmental agenda. All existing and new developmental programmes and projects shall incorporate disaster resilient specifications in design and construction. The Planning Commission will give due weightage to these factors while allocating resources.

NDMA's initiatives on Mainstreaming DRR

NDMA in cooperation with the Planning Commission and the Ministry of Finance (MoF) has set up appropriate mechanisms to ensure that all new projects involving infrastructure development and related construction adhere to disaster-resilient technology and safe siting. The revised project information formats of the Expenditure Finance Committee (EFC) and Detailed Project Report (DPR) address

these concerns. Instructions in this regard have already been issued to all the Central Ministries by the MoF in June 2009. The process of self-certification is to be followed with a view to ensure that there is no delay in project implementation. The design of all new and ongoing projects/programmes will thus be addressed from the point of view of DM concerns, while existing infrastructure will be selectively reviewed for appropriate mitigation measures. Besides this, NDMA has also requested the State Governments to implement similar procedures of DM audit for projects/programmes under their purview.

9.3 Role of Nodal Ministry

9.3.1 The nodal ministry will evolve its DM plans for holistic and coordinated management of urban flood emergency. To sustain an integrated approach to urban flood DM, the Central Government needs to make arrangements for implementing the National Plan on an inter-ministerial or inter-institutional basis so that the interests of the concerned ministries, States/UTs and all stakeholders are taken care of. The agenda of these Guidelines will also be implemented by the governments of various States and UTs through the ULBs. The experience gained in the initial phase of the implementation is of immense value, to be utilised not only to make mid-course corrections, but also to make long-term policies and guidelines after a comprehensive review of the effectiveness of DM plans, undertaken in the short-term.

9.3.2 All States and UTs coordinate efforts by the ULBs to develop their DM plans through an extensive consultative approach, covering all stakeholders and in conjunction with the CDMPs. The ULBs generally do not have the necessary technical capability and resources and therefore special efforts are necessary for strengthening them. The role of the nodal ministry becomes very important in providing/facilitating such efforts, by providing a technical umbrella and also structure such efforts as a part of various national missions/initiatives.

9.3.3 The Guidelines provide for strengthening urban flooding DM in the country on a sustainable basis. These guidelines have set modest goals and objectives, to be achieved by mobilising all stakeholders through an inclusive and participative approach. Appropriate allocation of financial and other resources, including dedicated manpower and targeted capacity development, would be the key to the success of implementing the Guidelines.

9.4 Implementing the Guidelines

9.4.1 Implementing the Guidelines at the national level would begin with preparing the National Plan. The plan will spell out detailed work areas, activities and agencies responsible, and indicate targets and time-frames. The plan thus prepared will also specify indicators of progress to enable their monitoring and review. The National Plan will be prepared by NEC, based on the Guidelines, and implemented with the approval of NDMA.

9.4.2 The Ministries/Agencies concerned, in turn, will:

i) Provide guidance on the implementation of the plans to all stakeholders,

ii) Obtain periodic reports from the stakeholders on the progress of the implementation of DM plans,

iii) Evaluate the progress of the implementation of plans against the time-frames and take corrective measures, wherever needed,

iv) Disseminate the status of progress and issue further guidance on the implementation of plans to stakeholders, and

v) Report the progress of the implementation of National Plan to NDMA/ NEC.

9.4.3 MoUD will keep NDMA/NEC apprised of the progress of the implementation of their plans, related to improvement of the urban flood warning system on a regular basis.

9.4.4 SDMAs/ SECs will develop state/UT-level DM plans on the basis of these Guidelines. SDMAs will approve these and keep NDMA informed. The state departments/authorities concerned will implement and review the execution of DM plans at the district and local levels along the above lines.

9.5 Implementation and Coordination at the National Level

9.5.1 Planning, implementing, monitoring and evaluating are four facets of the comprehensive implementation of DM plans. NEC or the concerned ministries/ departments will identify appropriate agencies, institutions and specialists with expertise in relevant fields, and involve them in various activities to help implement Urban Flood DM plans, in accordance with the spirit of the National Guidelines, and keep NDMA periodically posted.

9.5.2 Separate groups of individuals or agencies will undertake each of the above-mentioned four sets of activities. Some individuals may be common to the first three groups. However, the fourth group, involved in evaluating the outcome of planning, executing and monitoring, needs to consist of specialists who are not directly involved in any of first three groups. This will help in getting an objective feedback on the effectiveness of the implementation of these Guidelines. The availability of professional expertise is, therefore, crucial for monitoring and successfully implementing the Urban Flood DM plan and it will be built up at all levels.

9.5.3 The Urban Flood DM framework also imposes additional responsibility on professionals to improve their skills and expertise, corresponding to best practices the world over and to contribute to capacity development, as well as cooperate with and form partnership with other stakeholders. Synergy among their activities can be achieved by developing detailed documents on how to implement each of the activities, envisaged in these Guidelines.

9.5.4 Procedures need to be developed to elaborate the monitoring mechanism to be employed for undertaking transparent, objective and independent review of activities outlined in these Guidelines. This process can be smooth and successful if a single window system is adopted for the conduct and documentation of each of the above four phases. Each of the stakeholder ministries, departments, government agencies and organisations will designate a nodal officer to facilitate this.

9.6 Institutional Mechanisms and Coordination at State and ULB Levels

9.6.1 On the lines of the measures indicated at the national level, SDMAs and DDMAs will also identify appropriate agencies, institutions and specialists with experience in relevant fields and involve them in various activities to help implement the UFDM plans. Likewise, measures indicated at the national level, such as designating a nodal officer in each line department, will achieve similar objectives.

9.6.2 The State will also allocate and provide the necessary finances for the efficient implementation of these plans. Similarly, district and ULB level plans will be developed and the need to follow a professional approach will be reinforced. SDMAs will work out, along with various stakeholders, suitable mechanisms for the active involvement of associations of professional experts for planning, implementing and monitoring DM initiatives. These activities are to be taken up in a project mode, with a specifically earmarked budget (both plan and non-plan) with each activity and to be implemented in a fixed time-frame.

9.6.3 The approach followed will emphasise comprehensive urban flooding safety and risk-reduction measures, including technical and non-technical preparedness measures. It will be environment and technology-friendly, sensitive to the special requirements of vulnerable groups and address all stakeholders involved in Urban Flood DM. This will be achieved through strict compliance with existing and new policies.

9.6.4 As brought out in section 5.17 of this document, there is a need to define the role of DM cell in ULBs putting them at the centre-stage of all DM related activities at the ULB level. Besides, the state departments will designate a nodal officer not below the rank of a joint secretary to coordinate all DM related work of the ULBs.

9.7 Financial Arrangements for Implementation

9.7.1 For too long, DM in India was marginalised as an issue of providing relief and rehabilitation to the people affected by natural calamities. The new vision of GoI is a paradigm shift in the approach to DM – from the erstwhile relief-and-response-centric approach to a holistic and integrated approach — which will also be a pro-active prevention, mitigation and preparedness driven approach. These efforts will conserve developmental gains, besides minimising loss to lives, livelihood and property. This should, therefore, be the underlying principle for the allocation of adequate funds at all levels for prevention, mitigation and preparedness, along with strengthening the relief and rehabilitation machinery.

9.7.2. The return on investment on mitigation measures is very high. According to WMO, US $1 invested in disaster mitigation can prevent about US $7-worth of disaster related economic losses. It is also usually said that 'you pay something for doing' and 'pay much more for not doing'. Thus, financial strategies will be worked out in such a way that necessary funds are in place and their flow for implementing the UFDM plan is organised on a priority basis.

9.7.3 The sources of funding for all UFDM plan related activities will be as follows:

(i) Annual Plan/Budget: for mainstreaming UFDM plans into developmental plans of respective ministries/ departments

at the Centre and State governments/ UTs and ULBs,

(ii) Centrally Sponsored/Central Sector Schemes,

(iii) National Mitigation Projects by NDMA and other specific projects either by the Central Government or State Governments, funded internally/ externally, and

(iv) Public-Private Partnership.

9.7.4 The approval and disbursement of funds from multilateral agencies and other financial institutions to such developmental initiatives will be linked to their compliance with these norms in accordance with the techno-legal regime. The Department of Economic Affairs, Ministry of Finance, GoI, will ensure this. Similarly, states will also link approval and disbursement of funds, to compliance with norms. Interfacing of the techno-legal regime and financial measures that will contribute immensely to disaster risk reduction.

9.8 Implementation Model

9.8.1 These Guidelines will come into force with immediate effect. The phasing of the implementation model will include the short-term covering 0–2 years in Phase I; the medium-term covering 2–5 years in Phase II; and the long-term covering 5–8 years in Phase III. The DM plan will indicate detailed work areas and activities/targets with suggested time-frames and suitable indicators of progress along with the authorities/ stakeholders responsible for implementing the Guidelines. Different milestones and appropriate monitoring mechanisms will also be indicated.

9.8.2 The activities in Phase I will pose very serious challenges as they will lay the foundation for urban flood risk minimisation. In subsequent phases, the activities will be further intensified and special efforts will be made to consolidate the lessons of Phase I in mobilising more effective participation of stakeholders for achieving urban flood risk reduction.

9.8.3 Major action points are listed in Chapter 10 along with references to the sections under which they have been discussed. Implementing agencies and time-frames of implementation have been indicated. They will be taken into consideration while preparing and executing DM plans on a priority basis.

10 Summary of Action Points

Increasing trend of flooding in urban areas is a universal phenomenon and poses a great challenge to urban planners the world over. Even in India we have witnessed a similar trend. Problems associated with urban floods range from relatively local incidents to major incidents covering large areas resulting in inundation from a few hours to several days.

It can result in damage to property, relocation of people and loss of life. It can damage civil amenities and public and private property. It can also cause disruptions in transport and power supply bringing life to a grinding halt. All this leads to untold miseries and hardships. It also results in deterioration of water quality and secondary effects of possible epidemics and exposure to infection takes further toll in terms of loss of livelihood, human suffering, and in extreme cases, also loss of life.

Realizing that the causes of urban flooding are different and so also are the strategies to deal with them, NDMA has for the first time decided to address urban flooding as a separate disaster, delinking it from floods. The process of evolving the National Guidelines for Management of Urban Flooding has been very challenging since this is the first ever document being put together on this subject in India, looking at urban flooding in a holistic manner.

Coming to the preparation of the plans, it is advisable to adopt an 'all hazards' approach in handling urban flooding emergencies to optimise the use of resources. To facilitate easy reference to the stakeholders, some of the major recommendations are consolidated in this chapter. However, all the recommendations made in other chapters of the guidelines will be complied with, by the concerned authorities.

Chapter 3 Early Warning System and Communication

1. National Hydro-meteorological Network

CWC should maximize the real-time hydro-meteorological network to cover all the urban centers in support of the emerging priorities in dealing with urban flooding. The requirement will be assessed taking into consideration all cities/ towns which are particularly located on river banks, upstream and downstream of major and medium dams and island cities. Based on that assessment, CWC will initiate the process to prepare a plan and implementation strategy to seek the support of the government for commissioning such hydrological networks during the XII 5-year plan on priority (refer section 3.3).

[Action: CWC, MoUD and States/UTs]

2. Local Networks for Real-Time Rainfall Data

i) IMD will set up a 'Local Network Cell' in the IMD headquarters,

ii) Local Networks with ARGs will be installed in all 2325 Class I, II and III cities and towns with a density of 1 per 4 sq km. Class I cities will be covered by the end of 2012 and the rest by the end of 2015,

iii) The density will be further increased to 1 per sq km, based on the experience gained in urban flood management,

iv) The sampling of rainfall should be uniformly fixed between 5 to 15-minute interval depending upon topography to capture the high intensity rainfall data which is crucial for early warning, better response actions, future drainage design, and

v) EOCs will be set-up by the ULBs and connected to the ARG network (refer section 3.6).

[Action: MoUD, States/UTs, IMD, CWC and ULBs]

3. Doppler Weather Radars

i) DWRs will be calibrated with real-time rainfall data from the local networks,

ii) City/ town maps will be incorporated on the DWR images,

iii) Cities/ towns will be sub-divided on the basis of watersheds and a protocol will be developed for forecasting rainfall for urban areas on the basis of watershed,

iv) IMD and MoUD will work out a strategic expansion of DWR network in the country, on priority basis to cover all urban centres with specified time-lines, and

v) An appropriate redundancy plan for radar coverage of local systems with shorter radial coverage (30-50Km), using either 'C' or 'S' band radars will be worked out by a national level Standing Advisory Committee to guide suitable urban flood monitoring mechanisms (refer section 3.7).

[Action: IMD and MoUD]

4. Data Integration and Sharing

It is essential to design and strengthen local hydro-meteorological data networks to cater for the needs of urban flooding holistically. Coordination mechanism will be established among all agencies for deriving maximum benefit from the efforts of each individual organization (refer section 3.8).

[Action: IMD, CWC, MoUD, States/UTs, and ULBs]

5. Building as underlying sensor web flow

A dedicated high bandwidth communication channel is to be built, for ensuring smooth underlying sensor web flow of all available information and products (refer section 3.10.2).

[Action: DIT and SWAN]

6. Infrastructure and other Baseline Data

i) Data models will be built for urban infrastructure, involving geospatial approach with due procedures for data standardization, collation, quality check and annual updation, and

ii) Institutional mechanism will be evolved to share data/information with the institutions and other concerned authorities at local level. Information should be shared with states and vulnerable cities under the overall architecture of NUIS (refer section 3.11).

[Action: MoUD, NRSC, SoI, SRSACs and ULBs]

7. Operational Support

Responsibility for operation and maintenance (O&M) of all equipment set up by organisastions like the IMD/CWC etc will remain with the respective organisations. Facilities, exclusively setup by the ULBs, will be operated and maintained by them. It will be important to have a dedicated establishment at local levels for this purpose (refer section 3.13).

8. Measurement of Flood Levels

State-of-the-art automatic water level recorders must be installed throughout the drainage network of the watershed, which may sometimes extend beyond the administrative boundary of the ULB (refer section 3.14).

[Action: States/UTs and ULBs]

9. Decision Support System

The ULB will be responsible for developing step by step procedures and actions to be taken under each flood management strategy. Once the flood has been characterized, the associated flood SOPs will be immediately initiated (refer section 3.15).

[Action: States/UTs and ULBs]

10. Establishing Technical Umbrella for Urban Flood Forecasting and Warning (At the National Level)

A Standing Mechanism will be established for continuous guidance and support to the State and Local level initiatives to build and establish an integrated town/city specific UFDM Framework. It will be driven by NDMA and MoUD with representatives from related Ministries/ Departments /Agencies, States, and experts from IITs, other Institutes of national importance and service/professional bodies, as a part of this mechanism, to shoulder the responsibility for building an effective UFDM at the local scale with committed/continued technical support and operational infrastructure (refer section 3.18).

[Action: NDMA, MoUD IMD, CWC, SoI and NRSC]

11. Establishing Technical Umbrella for Urban Flood Forecasting and Warning (At the State Level)

State Nodal Departments will establish a State Level Guidance, Monitoring and Approval Mechanism for UFDM for building Effective Capacity Development/ Manpower Training/ Observational Network Design and Operational support. The ULB Scale Customization / Operation/ Upgrade and Update activities of UFDM will be shouldered by a Consortium of Local Level Technical Institutions (NITs, Engineering Colleges, etc.) for establishing GSM/WAN telemetry based ARG/AWS network; customization/testing/operation of urban flood EWS; customization of all necessary spatial and non-spatial data for building DSS for UFDM.

ULBs will extend all necessary administrative/financial/logistical support for the designated consortium of local level technical institutions to commission and operate the UFDM systems with due technical support/

manpower development teams on sustainable basis. ULBs need to organize an institutional back up, through developing appropriate MoUs with those technical institutions identified for this task (refer section 3.18).

[Action: MoUD, States/UTs, SRSACs and ULBs]

Chapter 4 Design and Management of Urban Drainage System

1. National Status-Storm Drainage Design Manual

The comprehensive Urban Storm Drainage Design Manual will be released by 2012. This will take into account current international practices, the specific locations and rainfall pattern of the cities and future needs. This will be updated/ revised as per practice followed internationally (refer section 4.3).

[Action:MoUD]

2. Stormwater Drainage System Inventory

i) An inventory of the existing stormwater drainage system will be prepared on a GIS platform,

ii) The inventory will be both watershed based to enable proper hydrologic and hydraulic analysis and ward based to enable coordinated administrative management,

iii) Minor systems should be mapped clearly showing the interconnections with the major system besides the cross connections with sewer lines, and

iv) Major systems with will be mapped clearly with delineation, demarcation and details of the cross-sections, slopes, drain crossings including natural formations and man made structures like bridge piers, transmission towers, service utilities and existing encroachments, etc. This should also take into account the sewer discharges (refer section 4.5).

[Action: MoUD, States/UTs and ULBs]

3. Catchment as basis for Design

Catchment will be the basis for planning and designing the stormwater drainage systems in all ULBs (refer section 4.7).

[Action: MoUD, States/UTs and ULBs]

4. Contour Data

Contour mapping of urban areas will be prepared at 0.2 to 0.5 m contour interval for detailed delineation of the watershed/ catchment for planning drainage systems (refer section 4.8).

[Action: MoUD, SoI, States/UTs and ULBs]

5. Thunderstorm Rainfall Intensity

i) IDF curves will be developed for each city, based on extraction of data from the raw data charts at 15- minutes resolution and from AWS at 5-minutes resolution, and

ii) IDF relationships will be adjusted, taking into account climate change impacts and urban heat island effects. At the very least, a trend analysis of short duration rainfall intensities will be carried out and if an increasing trend in the recent years is shown, higher intensities than those provided by IDF relationships will be used for resizing existing

systems and design of new systems, especially for critical infrastructure like airports, major roads and railway tracks (refer section 4.10.1).

[Action: States/UTs and ULBs]

6. Runoff Coefficient for Long Term Planning

All future stormwater drainage systems will be designed taking into consideration a runoff coefficient of upto C = 0.95 for estimating peak discharge using the rational method, taking into consideration the approved land-use pattern of the city (refer section 4.11).

[Action: MoUD, States/UTs and ULBs]

7. Operation and Maintenance

i) Pre-monsoon desilting of all major drains will be completed by March 31 each year,

ii) Besides the pre-monsoon de-silting of drains, the periodicity of cleaning drains should be worked out, based on the local conditions. The roster of cleaning of such drains should be worked out and strictly followed,

iii) All waste removed both from the major and the minor drains should not be allowed to remain outside the drain for drying, instead the wet silt should be deposited into a seamless container and transported as soon as it is taken out from the drain. In exceptional cases, the silt may be allowed to dry for about 4 to 24 hours outside the drain before transporting the semi-solid silt for disposal,

iv) Completion of work will be certified by representatives of local RWAs/ SDAs/ Municipal Ward Committee members and Area Sabha members besides third party certification. An appropriate mechanism will be evolved to ensure this,

v) The Manual on Solid Waste brought out by the CPHEEO, MoUD, (2000) will be followed in cleaning shallow surface drains,

vi) The amount of solid waste generated varies from catchment to catchment and depends on the type of locality, population, their affluence, etc. Suitable interventions in the drainage system like traps, communitors, trash racks can reduce the amount of solid waste going into the storm sewers,

vii) Land will also be identified for locating such structures along the drains. The design of such structures will be based on actual field measurements at the proposed site rather than generic values from a single site,

viii) Due consideration will be given to internationally available technology for removal of solid waste from storm-water drains,

ix) De-silting of minor drains will be carried out as part of a regular preventive maintenance schedule. The catchment will be the basis for planning this, as a part of the watershed de-silting master plan,

x) Cleaning of minor drains will be taken up from the outlet end to upstream side,

xi) Ageing systems will be replaced on an urgent basis,

xii) A master plan will be prepared to improve the coverage of the sewerage system, so that sewage will not be discharged into stormwater drains, and

xiii) Adequate budget will be provided to take care of the men, material, equipment and machinery. Special funds will be provided for the safety equipment of the personnel, carrying out maintenance of underground man-entry sewers (refer section 4.12).

[Action: MoUD, States/UTs, ULBs]

8. Special Design Considerations

i) Airports are critical infrastructure. Keeping the airports operational under conditions of severe flooding, will be very crucial for rushing emergency supplies. Even in the event of the arterial roads being flooded, helicopters can be used to rush supplies received at the airports to the affected areas, and

ii) It is, therefore, of utmost importance that these will be made flood-proof by providing efficient drainage for a much higher rainfall intensity and using Best Management Practices like provision of holding ponds (refer section 4.13.1).

[Action: Ministry of Civil Aviation, States/UTs and ULBs]

9. City bridges

All future road and rail bridges in cities crossing drains should be designed such that they do not block the flows resulting in backwater effect (refer section 4.13.2).

[Action: States/UTs and ULBs]

10. City road levels

All road re-levelling works or strengthening/overlay works will be carried out by milling the existing layers of the road and recycling of materials obtained as a result of the milling so that the road levels will be not be allowed to increase (refer section 4.13.3).

[Action: States/UTs and ULBs]

11. Drain Inlet Connectivity

Inlets should be provided on the roads to drain water to the roadside drains and these should be designed based on current national and international practices. Indian Standard IS 5961 provides the design details for cast iron grating for drainage (refer section 4.13.4).

[Action: States/UTs and ULBs]

12. Rainwater Harvesting

Every building in an urban area will have rainwater harvesting as an integral component of the building utility. ULBs will ensure that this is implemented (refer section 4.16).

[Action: States/UTs and ULBs]

13. Rain Gardens

Concept of Rain Gardens will be incorporated in planning for public parks and on-site stormwater management for larger colonies and sites that are to be developed. People will be encouraged to adopt this concept even for sites already developed (refer section 4.17).

[Action: States/UTs and ULBs]

14. Water Bodies

All urban water bodies will be protected. Efforts will also be made to restore water bodies by de-silting and taking other measures. Efforts will also be made to revive water bodies that have been put to other uses. Water bodies will

be an integral part of the stormwater system (refer section 4.18).

[Action: States, ULBs]

15. Detention Ponds

Urban stormwater management systems will include detention and retention facilities to mitigate the negative impact of urbanization on stormwater drainage (refer section 4.19).

[Action: States/UTs and ULBs]

16. Lined Channels

i) Rigid lining will be implemented in high density urban areas where space is a constraint, and

ii) Flexible linings will be provided in medium and low density areas and new urban developments, as these permit infiltration and are environmentally friendly, providing habitat for flora and fauna and are less expensive (refer section 4.20).

[Action: States/UTs and ULBs]

17. Integrated Planning and Interactions between Water and Solid Waste Management

i) Integrated planning and co-ordination will be ensured to take into account all components of the urban water systems, and

ii) BMPs should be adopted by all ULBs to reduce the load on the major drainage system (refer section 4.21).

[Action: States/UTs and ULBs]

18. Specific Adaptation Strategies for Cities

i) Low-lying areas should be reserved for parks and other low-impact human activities,

ii) Wherever unavoidable, buildings in low-lying areas should be constructed on stilts above the High Flood Level (HFL) / Full Tank Level (FTL),

iii) For chronic flooding spots, alternate locations may be explored for accommodating people staying there,

iv) Buildings should be constructed on stilts after taking into account the stability of slopes, and

v) Stormwater drainage systems for coastal cities have to be designed taking into account the tidal variations (refer section 4.22).

[Action: MoUD, States/UTs and ULBs]

19. Encroachments

i) Encroachments on nallahs/ drains/ watercourses will be removed by providing alternative accommodation to the BPL people and appropriarte rehabilitation package for other categories of people,

ii) The nallahs/ drains/ watercourses/ flood plains should be clearly delineated and boundaries fixed in new developments. There will be strict enforcement of the relevant byelaws/regulations in the new layouts as discussed in Chapter 6, and

iii) Any encroachment on the drain will attract penal action and be treated as a cognizable offence, both against the encroachers and the officials responsible for enforcement of the byelaws/ regulations (refer section 4.23).

[Action: MoUD, States/UTs and ULBs]

Chapter 5 Urban Flood Disaster Risk Management

1. Issues in Urban Flood Disaster Risk Management

Decisions for new development (properties and infrastructure) are often taken without a full understanding of the risks of flooding. Consideration of new developments, on a case-by-case basis, can ignore cumulative stormwater effects on flood risks. As organisations manage different parts of the urban drainage infrastructure, they make investment decisions based on a limited cost-benefit analysis that rarely considers the wider drainage issues. The sum total of these individual and piecemeal investment strategies is unlikely to produce the most effective solution. MoUD will ensure that this is appropriately reviewed on a regular basis (refer section 5.2).

[Action: MoUD and States/UTs]

2. Risk, Hazard Assessment and Mapping

i) Risk assessment will be carried out with a multi-hazard concept leading to foolproof land use planning,

ii) Quantification of risks will start with the analysis of hydro-meteorological data and the hydraulic simulation of floods, and

iii) Flood hazard assessment will be made for standard baseline conditions to ascertain level of acceptable risk of flooding on the basis of projected future scenarios of rainfall intensities and duration and land use changes (refer section 5.4).

[Action: CWC, SoI, NRSC and SRSACs]

3. Estimation of Possible Inundation levels

The magnitude of inundation levels due to various scenarios and causes will be simulated on GIS-based inundation model, duly incorporating drainage capacities in the analysis in order to estimate depth, duration and extent of inundation by using an integrated city specific framework (refer section 5.5).

[Action: CWC, NRSC and SRSACs]

4. Estimation of Flood Damages

In general, the assessment of potential damages will be on the following basis (Actual damages will be on the basis of a field survey):

i) Identification of potential damage areas, according to the physical characteristics of the area such as land use, topography, drainage area, outfall system and the capacity of the existing stormwater drainage system. Maps are usually prepared to visualise the results of the identification process,

ii) Selection of damage categories, which are considered appropriate for each damage area under investigation. These are: public and private clean-up, structural and vehicular damage, damage of contents, traffic related losses and tax revenue losses,

iii) Developing unit-cost relationships for various damage categories,

iv) Evaluation of hydraulic conditions such as the volume of ponding areas, street conveyance capacities, storm sewer capacities and inlet capacities,

v) Determination of the extent of flooding expected for several storms of different frequencies of occurrence,

vi) Estimating damages for the "do-nothing" alternative for different storm frequencies,

vii) Plotting corresponding damages versus probability, in order to measure the area under the curve which represents the average annual damage (base-line damage),

viii) Estimating residual damages in a similar manner, for various alternative plans under study,

ix) Calculating annual benefit as the difference between the estimated annual damage before and after the capital improvement, and

x) The estimated annual benefit may then be used in the cost-benefit analysis (refer section 5.6).

[Action: CWC, IMD, SoI, NRSC and SRSACs]

5. Ward level Risk Reduction and Vulnerability Assessment

Ward level Information System will have to be developed using high resolution satellite images/ aerial photos, integrated with socio-economic data covering natural resources and infrastructure facilities on appropriate scale (1:1000) at community level (refer section 5.7.1).

[Actions: SoI, NRSC, SRSACs, States/ UTs and ULBs]

6. Insurance and Risk Transfer

i) Research on how floods threaten vulnerable urban populations and how they are affected must be developed in order to develop the best strategies for disaster mitigation. The research should be set in the Indian techno-legal context and draw from the Indian experience. The research should focus on three key areas: risk identification, risk pooling and risk transfer. The risk should focus on both property and people, and

ii) States/UTs will build partnerships with public/ private insurance companies and civil society to sensitive communities about available schemes and also develop appropriate micro-insurance schemes targeted at low-income groups. The partnerships should be based upon need, post performance, key objectives and cost effectiveness. A database of partners should be available in the public domain (refer section 5.8.4).

[Action: States/UTs and ULBs]

7. National Database for Mapping Attributes

i) The database required for mapping different ward/community level attributes will be made accessible to all ULBs and concerned departments/ agencies/ stakeholders,

ii) Integration between hardware and software will be ensured for compatibility and interoperability of computing, visual and networking infrastructure nodes at the centre and state/ ULB/ward levels, and

iii) Coastal ULBs/ Urban Development Authorities will work out micro-level analytical tools with appropriate interfaces to DSSs for planning and executing suitable risk reduction activities (refer section 5.10).

[Action: MoUD, States/UTs and ULBs]

8. National Urban Information System

i) All Class I, II and III Towns with population of 20,000 or more (on the basis of 2001 Census) will be mapped on the GIS platform under the NUIS,

ii) The database of the NUIS will be expanded to cover infrastructure facilities at community level integrated with socio-economic data, and

iii) Maps will be generating at 0.2-0.5 m contour intervals (refer section 5.11).

[Action: MoUD and SoI]

9. State Urban Flood Disaster Management Information System

The Technical Umbrella at the state level will ensure the establishment of a comprehensive UFDMIS (refer section 5.12).

[Action: States/ UTs]

10. Data Providers for Disaster Risk Management

a) Standards and interoperability protocols will be implemented by stakeholders,

b) Logically, all the producing and updating agencies manage their sectoral datasets during their everyday business and emergency situations. If the results of such data production and updating efforts are physically recorded, the required data/information for disaster response is always available to the producer. If this information is shared and exchanged, datasets will be accessible to a wider emergency management community, and

c) A committee set up by NDMA will be empowered to review the data needs and make data sets available to all stakeholders for holistic DM (refer section 5.13).

[Action: NDMA, SDMAs and ULBs]

11. Updating of Database through Additional Surveys

Efforts will be made for generating specific core data on priority (refer section 5.14).

[Action: DST/SoI, DoS/NRSC and SRSACs]

12. Updating of Database through Additional Surveys

Spatial databases will be standardized with provision for frequent updates and automated procedures/ tools for organising the collected data, as per NSDI and NDEM spatial frameworks (refer section 5.14).

[Action: SoI and NRSC]

13. Urban Flooding Cells (National Level)

It is for the first time that Urban Flooding is being dealt with as a separate disaster, de-linking it from riverine floods which affect the rural areas. MoUD is being designated as the Nodal Ministry for Urban Flooding.

i) A separate UFC will be constituted within MoUD,

ii) A Joint Secretary cadre officer will be designated as the Nodal Officer in-charge,

iii) It will play a lead role in the establishment of the Technical Umbrella at the national level,

iv) It will coordinate all UFDM efforts by different stakehiolders at the national level,

v) It will guide the states on all aspects of UFDM, and

vi) It will guide efforts for the preparation of the Stormwater Drainage Manual and set up a standing mechanism for updating it as per international practice (refer section 5.17).

[Action: MoUD]

14. Urban Flooding Cells (States/UTs)

The Department of Municipal Administration/ Urban Development in the State/UT will be the nodal department for the management of urban flooding.

i) A separate Urban Flooding Cell will be constituted within nodal department,

ii) A Joint Secretary cadre officer will be designated as the Nodal Officer in charge,

iii) It will take the lead to establish a state level monitoring and approval mechanism for UFDM particularly as a part of the Technical Umbrella, and

iv) It will guide all the ULBs in all aspects of UFDM. UFC shall be formed with members from Irrigation Department, State Remote Sensing agency, Disaster Management Department, etc. to guide the ULBs, for both prior to the events as well as during the event (refer section 5.17).

[Action: MoUD and States/UTs]

15. The major responsibilities of the UFC will be as follows:

i) Preparation and implementation of DM Plan,

ii) Coordination within the local body,

iii) Coordination with agencies outside the ULBs whose activities have a bearing on urban flooding (the list of all such agencies/ orgainsations should be a part of the DM plan),

iv) Regular mock drills and preparedness exercises,

v) Conducting DM audit for all decisions activities and investments which could have a bearing on DM, covering both structural and non-structural measures including techno-legal regime,

vi) DM audit activities like construction of railway lines/roads/bridges/ transmission towers, etc by other departments,

vii) Careful monitoring of maintenance of stormwater drainage system and de-silting activities,

viii) Monitoring of activities like municipal solid waste disposal,

ix) Strengthening the involvement of local level orgainsations RWAs, Bastis, slum associations, etc.,

x) Encouraging Community Based Disaster Preparedness (CBDP) efforts,

xi) Launching of awareness generation campaigns,

xii) Documentation of events,

xiii) Regular enhancement of capacity development at all levels, and

xiv) A local official will be designated as nodal officer at the ward level (refer section 5.17).

[Action: States/UTs and ULBs]

Chapter 6 Techno-Legal Regime

1. Environmental Impact Assessment

i) Stormwater drainage concerns will be made a part of all EIA norms, and

ii) Sometimes to overcome compliance to EIA, projects are split into smaller areas. Guidelines will be issued to State EIA Authorities to subject even smaller projects to meet EIA norms (refer section 6.4.7).

[Action: MoEF, MoUD, States/UTs]

2. MoUD will play a key role in coordinating the efforts of the states regarding the compliance with Techno-legal Regime by all the ULBs in their respective states.

i) Review the present status and bring all states on par relating to making amendments to development control regulations and building byelaws on the basis of the recommendations of the Experts Committee, set up by MHA in 2004,

ii) Issue guidelines for setting up a standing mechanism for a regular review to suggest periodic changes based on lessons learned and experiences and BMPs within and outside the country,

iii) Issue guidelines for making the techno-legal framework as an essential part of technical capacity development at all levels of state governments and ULBs, besides all other stakeholders,

iv) Prepare guidelines for mandatory third party compliance review of all land use and developmental plans, involving experts rom local S&T and Academic institutions,

v) Prepare necessary guidelines for evaluating cities/towns to be considered for annual awards for best record of compliance with techno-legal regime. Cities / towns will be considered under different categories like metros with 4 million plus population, cities with one million plus (less than 4 million) population and cities with less than one million population. Besides, smaller municipalities should also be considered under two or three categories,

vi) Review procedure for licensing architects with emphasis on compliance with techno-legal regime, and

vii) Sanction of new projects will be linked to proper implementation of techno-legal regimes by the ULBs (refer sections 6.3, 6.4, 6.5, 6.6).

[Action: MoUD/TCPO, States/UTs and ULBs]

3. Urban Sprawl

Growth of urban sprawls will result in change in land-use and land cover with impacts such as loss of agricultural land, open space, and ecologically sensitive habitats. This will ultimately have future implications in terms of urban flooding. All such concerns will be addressed by the states on priority. MoUD will review this with the states/ UTs (refer section 6.7).

[Action: MoUD, States/UTs]

Chapter 7 Response

1. Adverse Impact of Urban Flooding

Steps will be taken for business continuity plan by local Federations of Commerce and Trade and organisations like

CII, FICCI, ASSOCHAM and NASSCOM. State governments will coordinate these efforts (refer section 7.1.1).

[Action: States/UTs]

2. City Disaster Management Plan

CDMPs will be prepared taking into account UFDM concerns (refer section 7.2).

[Action: States/UTs and ULBs]

3. Incident Response System

i) Officials will be designated by name at all levels to discharge various responsibilities under the IRS, and

ii) List of these pre-designated officials with telephone numbers will be given wide publicity through media and other printed publicity material, to be freely made available to all stakeholder groups (refer section 7.3.3).

[Action: ULBs]

4. Evacuation Plan

Emergency evacuation plans will be developed with an institutional checklist of emergency actions (refer section 7.4.1).

[Action: ULBs]

5. Flood Shelters

i) Buildings will be designated as Flood Shelters and all necessary arrangements will be ensured ahead of the flood season, and

ii) Additional temporary arrangements will be made for water, sanitation, etc. (refer section 7.4.2).

[Action: ULBs]

6. Search and Rescue

i) Community level teams will play an important role in planning and assisting in this and work in coordination with the official machinery, and

ii) The municipal staff also works in close coordination with revenue administration (refer section 7.4.3).

[Action: ULBs]

7. Sanitation

Children, women, the aged and the differently-abled persons will be given special attention (refer section 7.4.5).

[Action: ULBs]

8. Flood Hotspots

i) Pre-flood season mitigation measures will be taken, and

ii) Post-flood review and identification of any fresh hot-spots will be done on a regular basis (refer section 7.4.6).

[Action: ULBs]

9 Chronic Flooding Areas

These spots should be properly identified in the CDMP and response actions planned well in advanced, taking both the physical and social vulnerability into account (refer section 7.4.7).

[Action: ULBs]

10. NDRF and SDRF

Periodic simulation exercises and mock drills will be organised and made mandatory on the lines of pilot initiatives of NDMA for ensuring effective, functional emergency response, along with the inventory of community resources and assets (refer section 7.5.1).

[Action: States/UTs and ULBs]

11. Fire Brigade

i) Since Fire is a municipal subject, a uniform policy is required which will

be applicable in all States. Steps will be taken by all the states/UTs to have the fire services under the Municipal Corporation/ Municipality, for at least the larger cities/ towns,

ii) States/ UTs will take necessary steps to systematically strengthen fire services by making provisions in their annual plans, and

iii) The 13th Finance Commission recommended that a portion of the grants provided to the (ULBs) be spent on revamping of the fire services within their respective jurisdictions. These bodies could provide financial support to the State Fire Services Department towards this objective. In this process, ULBs could draw upon the expertise of state agencies and the National Disaster Management Authority, as required (refer section 7.5.3).

[Action: MoUD, States/UTs and ULBs]

12. Local Emergency Squads

i) The emergency squads will be oriented to deal with such situations and will be provided with necessary training and equipment as mentioned in the DM Plan, and

ii) Equipment will invariably include pumpsets of required capacities in suficient numbers (refer section 7.5.4).

[Action: ULBs]

13. Preparedness

Local scale emergency medical response systems will be established to deal with medical preparedness, emergency treatment, mortuary facilities and disposal of bodies and carcasses, public health issues including trauma and control of epidemics (refer section 7.6.1).

[Action: States/UTs and ULBs]

14. Emergency Medical Response

i) Risk knowledge will be linked with local scale response plans by organizing necessary support systems from national agencies, in accordance with needs of the local authorities and community stakeholder groups, and

ii) Institutionalised multi-agency collaboration will be developed with clarity of roles and responsibilities from city to ward levels and periodic updating of SOPs at different levels based on experience gained (refer section 7.6.2).

[Action: States/UTs]

15. Involvement of the Corporate Sector

i) Strengthening of IDRN activity with updating of information will be carried out on a regular basis (refer section 7.7.3).

[Action: MHA]

ii) Each ULB should involve the corporate sector in making available their services and resources for emergency response. This should form an essential part of DM plan. All available resources should be documented. The IDRN should also be used during response (refer section 7.7).

[Action: States/UTs and ULBs]

16. Challenges to Evolve Disaster Response Capability

a) Restoration of power, telecommunications, road and railway transport will get top priority, and

b) A system to determine the safety of relief and relocation infrastructure, capacities of the emergency evacuation machinery and integrated support of emergency health care, night rescue, restoration of energy and food supply, etc., will be institutionalized (refer section 7.9).

[Action: States/UTs and ULBs]

Chapter 8 Capacity Development, Awareness Generation and Documentation

1. Urban Flood Education

i) Disaster-related curricula have already been introduced by the Central Board of Secondary Education (CBSE) for classes VIII, IX and X. It has to be clearly brought out that Urban Flooding is different from riverine flood which largely affects rural areas. The MoUD, in consultation with the MHRD, will encourage the CBSE to introduce modules of UFDM in classes XI and XII as well. MoUD will consultation with MHRD and the state governments will promote the efforts the development of high-quality education materials, textbooks and field training. The state governments/ SDMAs will encourage their school boards to develop similar content in their school curriculum,

ii) Such efforts will address all aspects of UFDM inorder to inculcate a culture of prevention, mitigation and preparedness as well as effective and prompt response, relief, rehabilitation and recovery. Case histories of major flood events will be used as valuable inputs in the process,

iii) MoUD will lead efforts to invole All India Council of Technical Education (AICTE), University Grants Commission (UGC), Council of Architecture (COA), Institution of Engineers (IE) and the state governments to develop suitable modules for inclusion in the curricula of architecture and engineering courses in the Indian Institutes of Technology (IITs), National Institutes of Technology (NITs) and other universities, colleges and polytechnics of engineering and architecture to equip the students with the requisite knowledge of flood-proof design and construction techniques,

iv) DM related aspects of medical education will receive detailed attention at different levels, so that graduating doctors, paramedics and emergency medical technicians are able to handle emergencies with a better understanding of the issues involved. One of the major public health concerns in management of urban flooding is the possibility of breakout of epidemics after a severe flooding event. Besides this, trauma care and emergency medical care are also very relevant,

v) The state governments will follow up these efforts with regular in-service refresher programmes at appropriate levels for upgradation of knowledge and skills, and

vi) There are some important human factors which contribute to urban flooding, namely, improper disposal of domestic, commercial and industrial solid waste and construction debris. These issues will be highlighted in curriculum developed by the states for schools. Implications of non-compliance of the techno-legal regime will also be included. Such efforts will go a long way in generating awareness from a young age and contribute to bringing a change (refer section 8.2).

[Action: MoUD, MHRD, MoHFW and States/UTs]

2. Institutional Capacity Development (Raising the Level of ATIs)

i) Efforts should be made to raise the level of ATIs. The faculty should become the nodal point of capacity enhancement in the state, be able to design and supervise the technical capacity programme initiatives of line departments. They should evolve suitable training modules by taking specific needs of the line departments in consultation with knowledge institutes, undertake research studies, and mock drills to improve preparedness and response capacities, design and development of databases, etc. to meet the emerging needs of the ULBs,

ii) The State/UT governments should designate a nodal officer in the department of MA&UD to work in close coordination with the DM cells of ATIs on one side and the commissioners of ULB on other side, and

iii) DM Cells of ATIs are to work in close coordination with state departments of MA&UD and Commissioners of ULBs to ensure capacity development programmes (refer section 8.4).

[Action: MoUD, NIDM, ATIs and States/UTs]

3. Community Capacity Development (Suggested Actions for Strengthening CBDM Efforts)

i) On the basis of the experience of the GoI–UNDP DRM Programme, a similar programme should be designed for the urban areas in a multi-hazard approach, with special emphasis on urban flooding,

ii) The adoption of community-based DRM, people-centred approaches, and the integration of DRM strategies into the socio-economic development planning, are critical for effective flood management strategies, and

iii) *In situ* flood management approaches should ensure community preparedness. This includes participatory urban flood planning and management involving both local government and the community. Communities should also be empowered to develop their own hazard mapping and evacuation strategy. The critical role of NGOs

in reducing community risks and vulnerabilities to disasters need to be considered (refer section 8.5).

[Action: MoUD and States/UTs]

4. Role of Civil Society

Civil Society needs to consider the enhancement of the socio-economic conditions of the poor, alleviate poverty and improvement of livelihood of these vulnerable groups (refer section 8.7).

[Action: States/UTs and ULBs]

5. Suggestions for Establishing Effective Community Level First Responder Support

i) Encourage local residents to constitute consisting of ex-servicemen, retired police personnel, paramilitary forces and RWAs,

ii) The owners/ those connected with management of organisation which generates bulk solid waste in commercial areass running of hospitals, hostels, community halls, hotels and restaurants,

iii) These people should be encouraged to be part of the TF/VG,

iv) The VG can be trained by the teams of Civil Defence, SDRF, NDRF, etc.,

v) Involve various youth organisations, namely (i) NCC, (ii) NSS, and NYKS to have the inherent advantage of outreach at the grass-root level and also have the advantage of ready availability for immediate assistance at the ground level in the event of any disaster, and

vi) Develop emergency response plans for hospitals and government offices (refer section 8.7.2).

[Action: States/UTs and ULBs]

6. Handling Societal Impacts of Urban Flooding

i) Suitable hedging mechanism, like insurance of life and property, need to be evolved to reduce urban flood vulnerability (refer section 8.8).

[Action: MoUD and States/UTs]

ii) Lack of technical capacity enhancement of domain-specific skills can severely paralyse the DM infrastructure and administrative mechanisms. Design and development of relevant educational and communication campaigns and launching them from time to time is important (refer section 8.8.9).

[Action: NIDM and ATIs]

7. Awareness Generation at Institutional Level

i) Public awareness will be created about the need to keep safety kits containing medicines, torch, identity cards, ration card, important documents and non-perishable eatables such as dry fruits, roasted channa, etc. ready before commencement of monsoon so that, they can carry the same with them, in case they have to be evacuated,

ii) The community will also be trained for preparation and utilisation of improvised flood rescue devices with household articles, and

iii) Specially designed public awareness programmes will be developed for

addressing the needs of physically handicapped and mentally challenged people, women and the elderly. The States Police Force, Civil Defence, Home Guards and SDRFs will also be covered by such efforts (refer section 8.13).

[Action: NDRF, States/UTs and ULBs]

8. Role of Public Representatives

Public representatives including Municipal Ward Members, MLAs and MPs are regularly elected by the people, directly or indirectly. They have a very close contact with the people at the grass-root level and their cooperation should be enlisted for various awareness generation programmes on a regular basis (refer section 8.14).

[Action: States/UTs and ULBs]

9. Role of Media

i) Steps will be taken to evolve appropriate media campaign covering radio, visual and print media besides the production of printed materials like brochures, pamphlets, posters, etc., and

ii) Media companies will also be motivated to launch/expand awareness generation programmes as a part of their CSR (refer section 8.15).

[Action: States/UTs and ULBs]

10. Awareness on Insurance

Awareness generation campaigns should be initiated by states/UTs, ULBs and other stakeholders. State governments, local authorities and other stakeholders are to communicate the benefits of insurance. This should be done with active cooperation from the insurance companies. MoUD should coordinate efforts for this (refer section 8.17).

[Action: States/UTs and ULBs]

11. Documentation

i) Documentation shall cover all aspects of early warning, communication, design and maintenance , successful actions/ failures and the results thereof, covering search and rescue, evacuation, management of flood shelters, food and water supply, restoration of essential services, public health issues, management of traffic and all other activities, and

ii) Basic format for documentation will be prepared by NIDM/ATIs (refer section 8.18).

[Action: NIDM, States/UTs and ATIs]

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