7. DISASTER MANAGEMENT

7.1 Natural Calamities

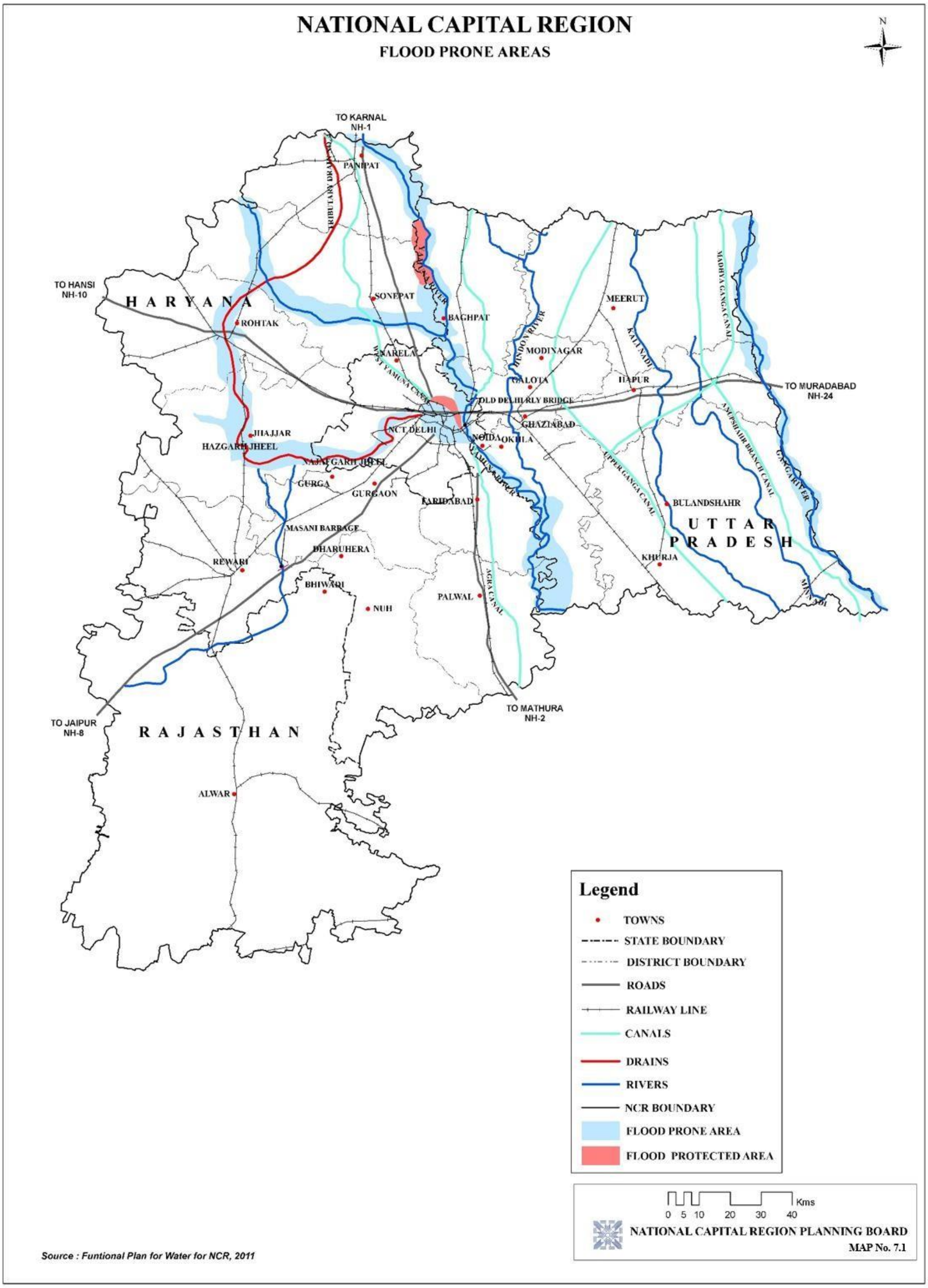
Geo-climatic conditions and rapid development of NCR makes it vulnerable to disasters, both natural disasters like flood, earthquakes, etc. and man-made disasters like fire, chemical or industrial accidents. While floods, as a recurring annual phenomenon, bring devastation in the region, earthquakes so far have caused higher casualties and emerged as a considerable threat. Natural calamities in NCR are elaborated in subsequent paragraphs.

7.2 Floods

The main causes of floods are heavy rainfall, inadequate drainage to carry away the rainwater quickly to streams/rivers, inadequate capacity of rivers to carry the high flood discharge, etc. Flash floods occur due to high rate of water flow and poor permeability of the soil. One of the reasons for damage of property and life due to floods is development of slums/unauthorized construction in the drainage channels, river beds etc. which are below high flood level area. Flood results in the outbreak of serious epidemics specially, malaria and cholera, simultaneously, scarcity of water.

Flood levels in Yamuna, the main river in NCR cross the danger level (204.22m.) almost every year and water spread out of the regime and reach the embankments. The flow and the expected flood levels of the river Yamuna in Delhi is forecasted by the Central Water Commission through hydrological and hydraulic observations on the upstream, particularly taken at Hathnikund headworks (about 130 km upstream) from where two canals namely Western Yamuna Canal (WYC) and Eastern Yamuna Canal (EYC). take off from the Yamuna river, Since the Hathnikund Barrage/headworks and the two canals have limited capacity, in the event of heavy precipitation in the catchment area of Yamuna and its tributaries, upstream of barrage the river downstream comes in spate, overflowing its banks and flooding the adjoining low lying areas. Also great damage is caused to areas deep inside the region because of the back flow in the drains which is otherwise meant to discharge excess water into the river. In addition, heavy precipitation within the region causes local flooding of streets and localities on a large scale. In recent years even moderate rainfall has resulted in local floods. Main reason for these local floods is high rate of runoff from urban areas which have been continuously growing at a very rapid rate. This problems of local floods is expected to aggravate in NCR because, almost the entire area is likely to get urbanized leaving very little scope for open and soft landscape surfaces, which help in absorbing runoffs and soften the impact of floods. The Flood Prone Areas in NCR has been shown in Map No. 7.1.

Map 7. 1 Flood Prone Areas in NCR



7.3 Regional Plan 2021- NCR Policies

Potential damage due to earthquake: Regional Plan 2021 stated that NCR falls in Seismic zone IV as per Seismic Zone map of Indian Standard IS 1893. This makes the area liable to

MSK intensity of "VIII" and is considered as High Risk Zone. Such intensity may cause severe damages some of which are listed below:

- Type A-Houses constructed with stone, rural structures, un-burnt bricks, clay etc. may suffer destruction causing gaps in walls, collapse of parts of buildings, loosening of cohesion of parts of buildings and collapse of inner walls.
- Type B-Buildings construction with ordinary bricks, large blocks, and natural stone and prefabricated type buildings may suffer heavy damage causing large & deep cracks in walls.
- Most buildings of Type C i.e., RCC buildings may have small cracks in walls, fall of large pieces of plaster, slipping off tiles, cracks/fall in chimneys etc.
- Fright and panic is caused among people, breaking off of branches of trees etc. takes place.

Liquefaction Effect: Groundwater, sand and soil combine during seismic shaking to form liquefaction during a moderate to powerful earthquake. When liquefaction takes place under buildings the foundations sink and the building collapse. Areas with sandy soil and groundwater close to the surface are far more at risk of liquefaction. Buildings can even sink into the ground if soil liquefaction occurs. Since NCR falls in Seismic Zone-IV, river beds / flood plains of NCR may be effected by liquefaction during occurrence of earthquake.

Floods: With regard to floods, Regional Plan-2021 has proposed that different areas in NCR, which are liable to flooding in rivers of return period of 5,10,25, 50 and 100 years, need to be identified on map for land use zoning at regional and Sub-regional levels. Participating States should prepare detailed Contour Maps for their respective Sub-regions on a scale of 1:15000 at a contour interval of 0.3 to 0.5 meter and mark areas that are flood prone.

Regional Plan-2021 for NCR identified rivers and tributaries of Yamuna, Ganga, Kali, Hindon and Sahibi, major lakes and water bodies such Badhkal Lake, Surajkund and Damdama and Siliserh lakes as Natural Conservation Zone and the broad policies for this zone are as under:

(i) The areas under water bodies i.e. rivers, ox-bow lakes, paleo-channels, lakes and ponds and their surrounding areas be kept free from any encroachment/development, to allow free flow of water. Construction activities for human habitation or for any other related purpose not be permitted. Suitable measures be taken the water bodies with the minimal flow/water level.

(ii) In the flood prone areas/river beds/banks, no construction or habitation activities be permitted. Flood Protection Plan be prepared by the concerned State Governments/ agencies. Policies proposed in the Disaster Management Chapter at para 15.5 be further elaborated in the Sub-regional Plans, Master/Development Plans and Flood Protection Plans.

7.4 Urban Flooding

Urban Flooding is different from rural flooding as urbanization leads to develop / constructed catchments Major cities in India have witnessed damage of vital infrastructure such as transportation, power and also incidents of epidemics. The main factors responsible for urban flooding are heavy rainfall during monsoons, increase in imperviousness which prevents percolation of rain water. 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.

There has been an increasing trend of urban flood disasters in India over the past several years and number of major cities have been severely affected. The most notable floods are Hyderabad (2000), Ahmedabad (2001), Chennai (2004), Mumbai (2005,) Surat (2006), Kolkata 2007, Jamshedpur (2008) and Guwahati (2010). In the case of NCT Delhi, the flood of 1978 has been highest recorded flood when river water level reached to 207.49 m. at Old Railway Bridge and a large areas like Model town etc. were submerged under deep water. The flood of same magnitude (209.92) m.) occurred in 1988 in NCT-Delhi. Floods were also occurred in 2002, 2003, 2009 and 2010 in NCT-Delhi and submerged a large areas. Some of the factors responsible for urban flooding are discussed below:

7.4.1 Urbanization and pressure on land

Urban areas are centres of administrative, industrial and commercial activities 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/ low lying areas/flood plains. In Indian cities and towns, large habitations are coming up on river beds /low-lying areas, often encroaching over drainage channels. In some cases, houses are constructed even on top of nallahs and drains.

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

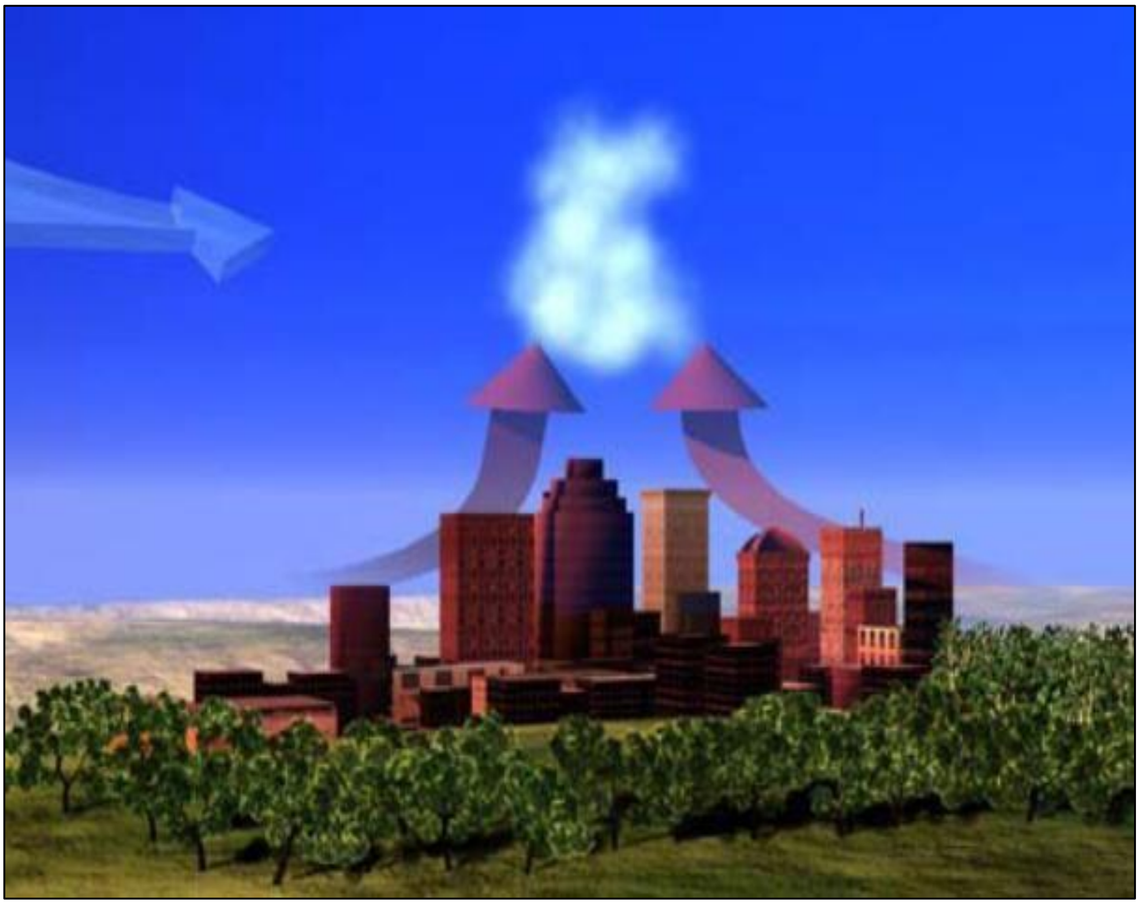
7.4.2 Increase in Imperviousness

Urbanization leads to increase in impervious areas in the cities/towns by way of constructed catchments i.e. roads, buildings, paved areas, and other concrete surface areas. The constructed catchments prevents percolation of rainwater and significantly increases the rate of runoff. This may increases flood peaks from 1.8 to 8 times and flood volumes by up to six times. Consequently flooding occurs very quickly due to faster flow times (in a matter of minutes

7.4.3 Urban Heat Island Effect - Increasing Rainfall

NDMA recognized that recent studies such as the Metropolitan Meteorological Experiment (METROMEX) conducted in St. Louis, USA, found that urbanization led to a 5-25 per cent increase in summer precipitation within and 5075 km downwind of the city. The Urban Heat Island Effect – the rising heat induces cloud formation while the winds interact with urban induced convection to produce downwind rainfall. (Figure 7.1 & Fig. 7.2) National Aeronautics and Space Administration (NASA) has indicated increased rainfall intensities over urban areas due to the Urban Heat Island Effect.

Figure 7-1 Rising Heat and Cloud Formation as a Result of the Urban Heat Island Effect



Source: National Aeronautics and Space Administration, USA

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

Figure 7-2 Winds Interact with Urban-induced Convection to Produce Downwind Rainfall

Source:*National Aeronautics and Space Administration, USA*

Factors contributing in Urban Flooding

Floods in urban areas can be attributed to one or a combination of different factors listed in Table 7.1.

Table 7.1 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 runoffs 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 resulting in backwater effect. • Indiscriminate disposal of solid waste • Failure to release water from dams resulting in back water effect.

Source: National Disaster Management Guidelines: Management of Urban Flooding, 2010

7.5 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, modelling/forecasting and decision-support systems. One way of improving the preparedness for urban flooding is by setting up a vulnerability-based geo-spatial framework to generate and analyze different scenarios (Refer **Box 7.1).** 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.

Box 7.1 Case Study Mumbai

Box-7.1: Case Study Mumbai
On 26th July 2005, Mumbai suffered severe flooding due to 944 mm rainfall in 24 hours. 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.

7.6 Flood Early Warning System

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. The meteorological forecasts prepared by India Meteorological Department (IMD), largely include a description of the current and forecasted meteorological weather situation, supplemented by information on the anticipated rainfall, temperature, wind velocity etc. for larger regions. Urban area hydrological forecasts need to be worked out for urban sectors and also covering large-scale suburban areas for rendering effective local scale / watershed scale urban flood warning. Interpretation of the meteorological and hydrological situation on continuous basis by the ULBs is critical for effectively responding to the emerging flood scenario.

7.7 Need for Comprehensive Approach for Urban Flooding

The urban flooding needs special attention on account of severity of the damage incurred to the loss of life and property. The present approach of rescue and relief centric need to be transformed to comprehensive Disaster Management (DM) approach as given in the Table 7.2 below:

Table 7.2 Approaches to the Management of Urban Floods

Rescue and Relief Centric Approach	Focus on	Holistic DM Approach
(i) Primary focus on hazards and disaster events (ii) Single, event-based scenarios (iii) Basic responsibility to respond to an event	Emphasis	(i) Primary focus on vulnerability and risk issues (ii) Dynamic, multiple risk issues and development of possible scenarios (iii) Fundamental need to assess, monitor and continuously update exposure to changing conditions.
(iv) Often fixed, location-specific conditions (v) Command and control, directed operations (vi) Established hierarchical relationships (vii) Often focused on hardware and equipment (viii) Dependent on specialized expertise	Operations	(iv) Extended, changing, shared or regional, local variations (v) Situation-specific functions (vi) Shifting, fluid and tangential relationships (vii) Dependent on related practices, abilities and knowledge base (viii) Specialized expertise, squared with public views and priorities
(ix) Urgent, immediate and short time frames in outlook, planning, attention, returns	Time Horizons	(ix) In addition to short term measures, moderate and long time frames in outlook, planning and returns
(x) Rapidly changing, dynamic information usage, often conflicting or sensitive (xi) Primary, authorized or singular information sources, need for definitive facts (xii) Directed "need to know" basis of information dissemination, availability (xiii) Operational/public information based on use of communications	Information use and Management	(x) Accumulated, historical, layered, updated, or comparative use of information (xi) Open or public information, multiple, diverse or changing sources differing perspectives, points of view. (xii) Multiple use, shared exchange, inter-sectoral use of information (xiii) Nodal communication

Source: National Disaster Management Guidelines: Management of Urban Flooding -2010, NDMA, Government of India

7.8 National Disaster Management Authority (NDMA) Guidelines

The guidelines are an important step towards the Development of Plans for the management of urban flooding. National Disaster Management Guidelines have been prepared by National Disaster Management Authority 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, failsafe, multi-disciplinary and multi-sector approach at various levels. The guidelines and key action points as suggested in National Disaster Management Guidelines-Management of Urban Flooding September 2010 are given below:

i) Ministry of Urban Development will be the Nodal Ministry for Urban Flooding.
ii) Establishment of the Urban Flooding Cell in Ministry of Urban Development, State Nodal Departments and Urban Local Bodies. iii) Establishing a Technical Umbrella for Urban Flood Forecasting and Warning both at the National Level and State/UT levels.
iv) 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.
v) Establishment of Local Network of Automatic Rainfall Gauges 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.
vi) IMD will establish a 'Local Network Cell.
vii) 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.
viii) Establishing Urban Flood Early Warning System.
ix) Catchments will be the basis for Design of Storm water Drainage System. Watershed will be the basis for all Urban Flooding Disaster Management Actions. All the 2325 Class I, II and III cities and towns will be mapped on the GIS platform.
x) Contour Mapping will be prepared at 0.2 - 0.5 m contour interval.
xi) Inventory of the existing storm water drainage system will be prepared on a GIS platform.
xii) Future Storm water 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.
xiii) Pre-Monsoon De-silting of Drains will be completed before March 31 every year.
xiv) Involve the Residents' Welfare Associations (RWAs) and Community Based Organizations (CBOs) in monitoring this and in all Urban Flood Disaster Management (UFDM) actions.
xv) Every building shall have Rainwater Harvesting as an integral component of the building utility.
xvi) Encroachments on Drains and in Floodplains will be removed by providing alternative accommodation to the poor people. xix) Better Compliance of the Techno-legal Regime will be ensured. Establish the Incident Response System for Coordinated Response Actions.
xx) Establish the Incident Response System for Coordinated Response Actions.
xxi) Capacity Development at the Community and Institutional level to enhance Urban Flood Disaster Management (UFDM) capabilities.
xxii) Massive Public Awareness programmes covering Solid Waste Disposal, problems of Encroachments, relevance of Techno-legal Regime besides all other important aspects.
xxiii) Involve elected Public Representatives in Awareness Generation.