

# Urban Floods– A Review

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**ABSTRACT:** In recent years, urban flooding has received considerable attention due its catastrophic impacts in terms of loss of lives, damage to properties and infrastructural facilities. The urban floods are hydro-logically and hydraulically different from sub urban floods. The urbanisation leads to developed catchments and in the event of heavy/ high intensity rain fall there is higher runoff which increases the flood peaks and flood volumes many times. Consequently, flooding occurs very quickly due to smaller lag times, sometimes in a matter of minutes. Urban flooding used to be primary concern for municipal and environmental governance, but now it has attained the status of 'disaster'. Challenges of urban flooding in terms of drainage and flood mitigation include structural and non-structural measures. Management of urban floods worldwide is undergoing a paradigm shift from approach of 'response and relief' to 'prevention and mitigation'. The most notable urban floods of India are the floods of 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 again in 2010. During these floods the normal city lives became standstill along with heavy traffic jams due to stagnant water on the streets. People have to stranded for weeks and economy activity get disrupted. The free flows of water over the streets and drains were observed during the flooding. The uneven distribution of high intensity short duration rainfall coupled with unplanned urbanisation, encroaching upon and filling up natural drainage channels and urban lakes to use the high-value urban land for buildings are the major causes of urban flooding. Various kinds of depression and low lying areas near or around the cities which were act as cushions and flood absorbers are gradually filled up and built upon due to urbanisation pressure. This results in reduced carrying capacity of drainage channel causing urban floods. Flood risk in urban areas are attributed to hazards which is further accelerated by growth in terms of population, housing, paved-up areas, waste disposal, vehicles, water use, etc. all contributing urban floods. Haphazard growth of low income habitations and un-organised trade added to challenge. Spatial dimensions of all these flood factors are often characterised by land-use. Land-use issues like decreased natural areas, loss of water bodies, encroachment of river/streams and other drainage channels, uncontrolled multiplication of built-up areas, have been identified as contributory factor to urban floods. The impact of urban flooding is further aggravated due to impact of climate change.

In this study, the hydrology and hydraulics of urban flooding along with the major causes of urban flooding are identified in contest of flooding which has occurred in the recent past in a few metropolitan such as Delhi, Mumbai, Chennai and Bengaluru in India. It is found that the short duration high intensity rainfall causing urban flooding increasing in these cities. Such an increase in rain fall intensities combined with rapid land use changes along with other factors may exacerbate the already critical situation of urban floods in the country. Urban flooding adds new disaster risks such as epidemics and may lead to deterioration of quality of life. An integrated approach, therefore, needs to be combined with watershed and land-use management along with development plan, engineering measures, flood preparedness, and emergency management in the affected lowlands, while taking into account the social and economic needs of communities in both the highland source areas, and also the lowland flood-prone areas. To meet the challenges of urban flooding city must be sustainable in terms of infrastructure and good governance with its citizens.

## I. INTRODUCTION

The hydrology and the hydraulics of urban and suburban floods are distinctly different. The three features of the hydrograph of an urban catchment distinguish the non urban catchment are (Majumdar and Saha, 2010):(a) the peak runoff occurs at a shorter time; (b) the magnitude of the peak discharge is higher, and (c) the total volume of runoff is larger. The time of concentration in an urban catchment is typically of the order of about an hour, and often much smaller than the sub catchments as against large time of concentration of the order of about 12 hours to a few days. The

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flood damage potential in urban area is also high due to population and property concentration in relatively small areas. Recent catastrophic floods in Indian cities (IRAD, 2013) such as 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 highlighted the importance of urban flood management in the country. Over the past few decades, rapid urbanisation with changing land use patterns has resulted in loss of flood plain storage and increased runoff. According to European Standard (EN 752), urban drainage system should be designed to withstand the flooding in the range of 10-50 years, depending on the type of urban. Some of the glimpse of the urban flooding of Indian cities are described below.

The objectives of this review is to identify the common causes of urban flooding in some of the important Indian cities and the lessons learnt from the past. Based on the review some observations are generalized which would be applicable to the other Indian cities as well. This review would be helpful to the decision maker for planning the strategy for flood management. Needless to mention that other location specific reasons and their solution would vary from location to location.

#### Floods in Delhi

From storm water drain point of view, Delhi can be divided in six drainage basins ultimately discharging into river Yamuna, namely- Najafgarh Drain, BarapulaahNallah, Wildlife sanctuary area discharging through Haryana, drainage of Shahdara area, Bawana drain basin and other drains directly falling into river Yamuna. The NCT of Delhi is prone to flooding from river Yamuna, its catchment in Haryana and from Sahibi River (Rajasthan) via Najafgarh drain. The low-lying Yamuna flood plains (Khadar) are also prone to recurrent floods. Due to fast urbanisation in Delhi during last four decades resulting in increase in paved area and decrease in the agricultural land which used to act as a percolation zone and is continuously depleting. Delhi normally remained flooded to the extent of 70000 hac (50% of its geographical area.

#### Floods in Mumbai

The Mumbai floods of July 2005 have proved to be eye opener and thereafter National Disaster Management Authority have decided to address the urban flooding as separate disaster in 2006 (NDM Guidelines 2010). In Mumbai 944mm of rainfall has occurred in 24 hours. The floods caused death of 450 people, residential areas were flooded and all means of transport were disturbed. The main causes of flooding in addition to heavy rainfall was the drainage conjunction and disruption of flow into the Mithi river.

#### Floods in Chennai

Since the beginning of the 20th century, Chennai has witnessed a steady deterioration of and decrease in water bodies and open spaces. It is estimated that in Chennai city more than half of the wetlands have been converted for other uses (Gupta and Nair 2010; Lavanya, 2012). Chennai had about 150 small and big water bodies in and around the city, but today the number has been reduced to 27. Ownership of water bodies is scattered among various government departments and is the root cause for lack of proper management. The Protection of Tanks and Eviction of Encroachment Act, came into effect on 1 October 2007. However, there has been lack of implementation of this law. The green cover reduced rapidly across the city between 1997 and 2001. In some wards almost 99% of the green cover has been replaced by non-vegetative development. As a result, the water-holding capacity of the city has gone down drastically.

#### Floods in Bangluru

Bangluru is located almost equidistant from both the eastern and western coasts of the South Indian peninsula. The mean annual rainfall is about 880 mm with about 60 rainy days a year. It is the fifth largest city of India with population of about 7 million, located around 100 km from the Kaveri River. There has been a growth of 632% in urban areas of Greater Bangalore across 37 years (1973–2009). Encroachment of wetlands, flood plains, etc. is causing floodway obstruction and loss of natural flood storage in Bangalore. In 2005, flooding had worsened by unauthorized developments along three lakes. Choked drains led to residential areas being inundated, and traffic was severely affected. Thousands of office-going persons were stranded on the city's waterlogged roads. Schools in the city were

closed and several apartment complexes were flooded. Water entered some office buildings, including one of the offices of India's third largest software exporter, WIPRO. The flood left hundreds of people homeless and ailing various health problems and environmental challenges. Enforcement of land-use laws and guidelines/plans has been observed to be poor. Field surveys (during July–August 2007) showed that nearly 66% of lakes are sewage-fed, 14% surrounded by slums and 72% showed loss of catchment area. Also, lake catchments were used as dumping yards for either municipal solid waste, construction residue or building debris. Bangaluru city has a 180 km long primary and secondary storm-water drainage system, which often fails to take the load of the rains due to silt and garbage causing blockage.

### **Important reasons of flooding in Delhi, Mumbai, Chennai and Bangluru**

Some of the major causes of floods in important Indian Cities are summarized below.

#### **Heavy Rainfall / Flash floods**

In India, 70 % of rainfall occurs in four months in south west monsoon. In many of the cities, the drainage system are found to be inadequate to meet the requirement, when there is heavy rain fall or flash floods. The existing drainage systems and storm water drains are blocked by slum dwellers, small shopkeepers, motor garages, garbage dumping etc resulting in obstruction of water flow and thus contributing immensely to the fury of floods

#### **Urbanisation**

Due to fast urbanisation over last three to four decades resulting in increase of paved area and decrease in the agricultural land which used to act as a percolation zone. The cross-sectional area of the drain has become inadequate resulting in frequent flooding of areas along the drains. Further unplanned urbanisation is also a key cause of flooding.

#### **Unauthorised colonies**

Large number of unauthorised colonies which have been developed on the open/agriculture land without consideration to the city plans, drainage, sewerage etc. and hence these cities are subjected to flooding during heavy rains. Many more settlements are coming up which would further increase drainage congestion and flooding.

#### **Siltation of drains**

Due to siltation in drains its carrying capacity is getting reduced and hence unable to carry the full discharge capacity and hence inundates the surrounding area. Even the old drainage and sewerage system has not been overhauled nor is it adequate now leading to poor water and sewerage management systems of cities.

#### **Sinking of water bodies**

Water bodies, low lying areas-water retaining plains, near or around the city which act as flood absorbers or cushion are gradually filled up and built upon due to urbanisation pressure resulting in urban flooding.

#### **Implications of Climate Change**

There is increasing concerns based on currently available evidence that anthropogenic activities have changed atmospheric composition leading to an increase in mean global temperature and alteration of meteorological processes that define climate (IPCC 2007).

#### **Management of Urban Flooding**

The urban flooding is a natural phenomenon and cannot be eliminated and bound to increase day by day. Hence the approach for flood management should shift to living with floods. The following strategy needs to be adopted for urban flood management.

#### **Construction of flood protection structures**

The various flood control structures like embankment along river near country side, bunds, spurs needs to constructed and if constructed requires maintenance and surveillance at regular intervals.

#### **Improvement of drainage efficiency**

De-silting, cleaning of road, gullies, removal of debris, solid waste materials from all drains should be undertaken at least before start of monsoon. The concerned authority should ensure that all drains are checked and cleaned before monsoon for effective drainage. De-silting reports and certificates should be obtained from all owning agencies before first week of June every year. Lining of drains may be done if needed.

#### **Renovation of water bodies**

All encroachments in and around the water bodies and flood plains should be cleared off and population inhabiting in the area have to be rehabilitated in other areas.

### **Rain water harvesting**

Rain Water Harvesting is very old concept since ancient times and plays a key role in arresting floods and urban water scarcity. Some of the important ways of rain harvesting are given as (a) On-channel storage of Rain Water in storm drains (b) Artificial Recharge Trenches (c) Check Dam (d) Development and deepening of village ponds (e) Providing Retention basins (f) Creation/Revival of (g) Construction of Tanks and water bodies (i) Roof top rain water harvesting

### **Data acquisition and scientific study about flood pattern**

There is an immediate requirement about the study of flood pattern at least for 5 years using hydrological and hydraulic modeling techniques which guides us with a strategic planning collectively. A rapid assessment of flood inundation mapping is required before the monsoon starts so as to effectively alleviate the flood risks. There is a need to create a data bank and the data should be made public for scientific study. The central agencies like IMD, CWC, IIRS etc. should take up the wide scale data collection and dissemination for the benefit of mankind.

### **Plantation of trees for sustaining water management for draught and flooding**

A mass drive for tree plantations should be carried out where-ever land is available and particularly on road sides, along drains etc. This will result in reducing soil erosion and run-off coefficient of the area and in turn reduce the flooding.

### **Land use and development planning**

The master plans of the city containing land use and drainage aspects should be prepared for the development of the city. The development authority should strictly follow the plans while developing the area. Certain area has been declared as reserved forests where construction of any kind should be prohibited. The land use and its planning along river sides should be monitored by Water Commission, Delhi.

### **An integrated approach in Flood control and Management**

An unified flood management agency at state level should be identified to acts as a nodal group to carry out the function of planning, co-ordination and monitoring of all the other concerned bodies in addition to the Disaster management agency.

### **Flood-plain zoning**

Flood plain zoning of the urban area should be carried out and the regulating agency should ensure its implementation.

### **Region Specific Measures**

There are certain city more prone to flooding due to certain causes while other city is more prone to certain other causes. For example, there are certain city near the coast which are vulnerable to floods due to cyclone on the other hand there are certain cities which are vulnerable to floods due to landslides. Hence site specific measures may be adopted to overcome the problem.

### **Public Awareness**

People should be made aware about the flood preparedness, response and mitigation measures. People participation in all development activity is key to success of the programme.

## **II. CONCLUSIONS**

This review finds the following as the major conclusions

1. The various water storage structures and natural drainage are either getting vanished or obstructed due to various reasons like unplanned development, deforestation, population growth etc. which leads to high flood magnitude of smaller duration and it ultimately leads to flooding.
2. Due to climate change rainfall patterns are changing leading to high intensity rainfall of small duration causing intense floods. This extreme event is observed to be rising day by day. It is also observed that the number of occurrence of rainfall decreases leading to unsustainable situation.
3. Most of the loss of lives and properties are observed to occur in the area where people got settled in the flood plain zones. There is a need to enforce the regulation so that human settlement is not permitted in the flood plain zones. This situation may be further aggravated if the area pertains in the zones of fragile Himalaya susceptible to earthquake and landslides.
4. The IMD rain gauge and CWC monitoring stations for rainfall and flood stage forecasting were not adequate for the past urban floods. Therefore more numbers of these stations should be augmented and monitored with support from

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state government. In addition short range satellite based forecasting systems may be development for flood warning and excavation.

5. There are certain measures like rain water harvesting and tree plantation which has been practiced from many year and have been found to solve many of the problems related to flooding. These measures have been adopted by many cities and needs to continue in future.

6. The disaster management plan needs to be initiated for each urban cities which should involve all stakeholders such as government, institutions, non- governmental organisation and the people concerned. This should be the collective responsibility and duty of each and every citizen of India to coordinate the various flood management activities.

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