

URBAN FLOODING AND ITS MANAGEMENT

1.0 INTRODUCTION

Flooding in general and urban flooding in particular is not a un- known event in world and in India. The un-even distribution of rain fall coupled with **Mindless urbanisation**, encroaching upon and filling up natural drainage channels and urban lakes to use the high-value urban land for buildings are the cause of urban flooding. The illegal filling of urban water bodies in cities like Calcutta, Delhi, and Hyderabad etc is a rampant. In Calcutta, for instance, Lake Town, badly situated, has not only suffered heavy floods in 1999 but also in 1970, 1978, 1984. The No. of water bodies in Delhi accounting for about 800 had now remained 600 and rest vanished. Thousands of illegal colonies have emerged in city and planning has been thrown to the winds resulting in constriction of natural drainage inviting urban floods. This paper deals with causes, effects, preventive measures to tackle urban flooding in general with focus on Delhi, the capital city of India.

2.0 DEFINITION

A **flood** is an excess of water (or mud) on land that's normally dry and is a **SITUATION** wherein the inundation is caused by high flow, or overflow of water in an established watercourse, such as a river, stream, or drainage ditch; or ponding of water at or near the point where the rain fell. This is a duration type event. A flood can strike anywhere without warning, occurs when a large volume of rain falls within a short time.

3.0 TYPES OF FLOODING

3.1 According to Duration Slow-Onset Flooding, Rapid-Onset Flooding, Flash Flooding.

3.2 According to Location Coastal Flooding, Arroyos Flooding, River Flooding and Urban Flooding. The urban area is paved with roads etc and the discharge of heavy rain can't absorbed into the ground due to drainage constraints leads to flooding of streets, underpasses, low lying areas and storm drains.

4.0 CAUSES OF URBAN FLOODING

4.1 Natural Causes

4.1.1 Heavy Rainfall / Flash floods Water of Heavy rainfall concentrates and flows quickly through urban paved area and impounded in to low lying area raising the water level. It creates more havoc when a main drain or a river passing through the area over-flows or breaches

4.1.2 Lack of Lakes Lakes can store the excess water and regulate the flow of water. When lakes become smaller, their ability to regulate the flow become less and hence flooding.

4.1.3 Silting The drains carry large amounts of sediments and deposited in the lower courses making beds shallower thus channel capacity is reduced. When there is heavy rain, these silted drains can't carry full discharge and result in flooding.

4.2 Human Causes

4.2.1 Population pressure Because of large amount of people, more materials are needed, like wood, land, food, etc. This aggravates overgrazing, over cultivation and soil erosion which increases the risk of flooding.

4.2.2 Deforestation Large areas of forests near the rivers/catchment of cities are used to make rooms for settlements, roads and farmlands and is being cleared due to which soil is quickly lost to drains. This raises the drain bed causing overflow and in turn urban flooding.

4.2.3 Trespassing on water storm drains The areas which were essentially created by the storm water drains to let their flood waters pass freely being tress-passed for developmental purposes result in obstruction of water flow and thus contributed immensely to the fury of floods.

4.2.4 Urbanisation leads to paving of surfaces which decreases ground absorption and increases the speed and amount of surface flow. The water rushes down suddenly into the streams from their catchment areas leading to a sudden rise in water level and flash floods. **Unplanned urbanisation is the key cause 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 inadequate channel capacity causing urban flooding.

4.2.5 Un Authorised colonies have been developed by the local colonisers on the agriculture land, earlier being used for crop has been purchased at lucrative prices from farmers, without consideration to the city plans ,drainage, sewerage etc. and thus subjected to flooding during heavy rain falls.

4.2.6 Poor Water and Sewerage Management Old drainage and sewerage system has not been overhauled nor is it adequate now .All the drainage and sewer system in many parts of Delhi has collapsed resulting in flooding. This can be seen during rainy seasons every year.

4.2.7 Lack of attention to the nature of hydrological system.

4.2.8 Lack of flood control measures.

4.2.9 Multiple authorities in a city but owning responsibility by none.



Urban-Flooding and effects

5.0 EFFECTS OF FLOODING/ FLOOD DAMAGES

The flooding affects every section of people, systems in a city, some of them are summarised below:

5.1 Economic effects

- Damage to Public buildings, Public utility works, housing and house –hold assets.
- Loss of earning in industry & trade
- Loss of earning to petty shopkeepers and workers
- Loss of employment to daily earners
- Loss of revenue due to Road, Railway Transportation Interruption
- High prices for essential commodities.

After flooding, government has to put many resources for aiding e.g., police force, fire control, aid workers and for restoration of flood affected structures, persons, live-stock etc. The flooding cause a great economic loss to the state, individual and to the society.

5.2. Environmental effects Damage to surroundings, forests, ridges, wild-life, zoo, urban community-trees, water bodies, shrubs, grass, fruits/vegetables in go downs etc result imbalance of eco-system of the city.

5.3. Effect on Traffic Flooding results in the damages of roads, collapse of bridges causing traffic congestion which affect day-to-day life and other transportation system.

5.4. Effect on Human Beings

- **Human lives:** Every year floods in India cause more than 50 lac people affected dead and become homeless.
- **Psychological impact** : The people of all ages who stranded in flooding suffer a great Psychological impact disturbing their whole life and the society as whole.

5.5. Live Stock : The live stock is the most affected living being due to urban floods. It is difficult to care for them particularly when human being itself is in trouble.

5.6. Disease : Flooding usually brings infectious diseases, e.g. military fever, pneumonic plagues, dermatopathia, dysentery, common cold, Dengue, break bone fever, etc. Chances of food poisoning also become more where electric supply interrupted in food-storage area due to flooding.

5.7. Public Inconveniences : The flooding causes impairment of transport and communication system due to which all people of all section get stranded e.g. school children, college students, office goers, vegetable, milk venders etc. The basic and essential commodities also do not reach to the common person. This result either starvation to poor persons or high priced to the common persons.



6.0 CASE STUDY - DELHI FLOODING

6.1 Geography Delhi is located at a latitude of 28°34' N and a longitude of 77° 07'E having an average elevation of 233 m (ranging from 213 to 305 m) above the mean sea level. The NCT has three local municipal corporations: Municipal Corporation of Delhi (providing civic amenities to an estimated 13.78 million people), New Delhi Municipal Council (New Delhi) and Delhi Cantonment Board. Total geographic area of Delhi is 1483 sq.Km (Rural-689 Sq.Km, urban-624 Sq.Km and forest- 170 Sq.Km.). Delhi can be divided into three major geographical regions: the Yamuna flood plain, the ridge and the Gangetic Plains.

6.2 Population: Delhi has attracted millions of people from Haryana, Punjab, Uttar Pradesh, Rajasthan and Bihar. Population of Delhi in 1911 was only 4.0 lac, in 1961 – 26.58 lac, in 1991- 70 lac and now it is 141 lacs. Population Density of Delhi is 9,294/km² (Urban 12361 and rural 1200). In 2021, population of Delhi is expected to 220 lac.

6.3 Climate of Delhi Delhi has a semi-arid climate with high variation between summer and winter temperatures. The average annual rainfall is approximately 670 mm (27 inches), most of which falls during the Monsoons, in July and August. The flood season observed by Delhi Govt is from July to October.

6.4 River Yamuna

The River Yamuna, a major tributary of river Ganges, originates from the **Yamunotri** glacier at an elevation of about 6387 meters above msl and it enters Delhi near **Palla** village making common boundary with UP and Haryana. The river flows in Delhi from Palla to Jaitpur for about 50 Km length. It is trapped at Wazirabad for water supply, at ITO and at Okhla barrages for regulating the water and then enters in UP.

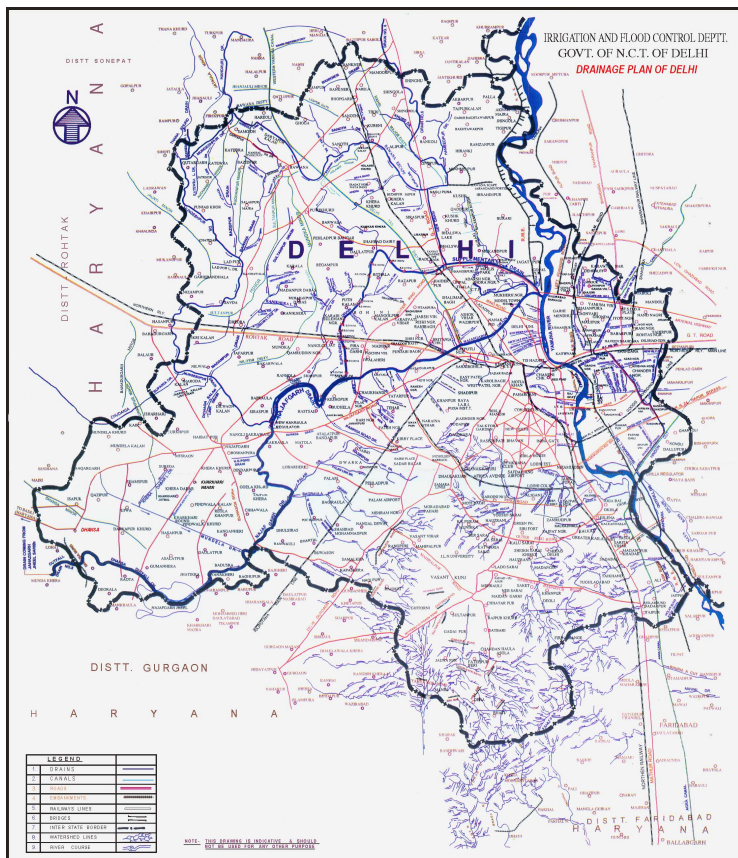
6.5 Floods in Delhi

From storm water drain point of view, Delhi can be divided in **six drainage basins ultimately discharging into river Yamuna, namely** - Najafgarh Drain, Barapulaah Nallah, Wildlife sanctuary area discharging thro` Haryana , Drainage of Shahdara area, Bawana drain basin and other drains directly out 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.

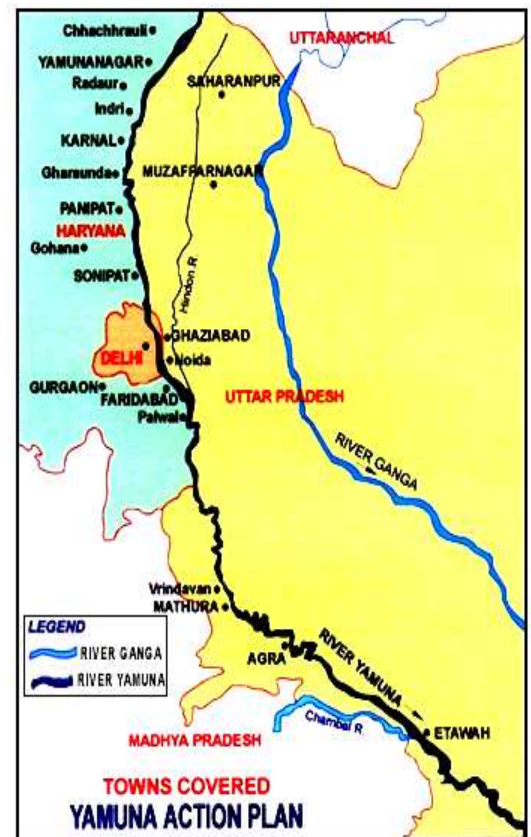
Due to fast urbanisation in Delhi during last four decades resulting in increase in paved area and decrease in the agricultural land which used to act as a percolation zone and is continuously depleting (Net Agriculture area sown in 1950-51 was 97067 hac, in 2005-06 is just 25000 hac out of total 148300 hac). Delhi normally remained flooded to the extent of 70000 hac (50% of its geographical area of 148300 hac from 1953 to 1984).

The Capital of India has suffered floods as back as in 1924, 1947, 1967, 1971, 1975, 1976, 1978, 1988, 1993, 1995, 1998 etc. **The 1978** was the worst ever flood in Delhi when water level reached at **207.49 m** (danger level is 204.83 m) with discharge **2.53 lac cusec** at old railway bridge (**7.0 lac cusec** discharge was released from Tajewala) when 130 villages and 25 urban colonies in Delhi were submerged in water. The right marginal bund between Palla and Bawana Escape out-fall also breached which caused a very large area of Alipur block and urban colonies like Adarsh Nagar, Model town, Mukerji Nagar submerged under deep water. On the left bank marginal bund reached the point of distress but could be saved by raising its height in certain reaches with earth filled bags. Damages nearly Rs.15 crores, eighteen lives, thousands of people rendered home less and 10 lac people were affected. During floods in **1993**, 206 localities, areas, colonies were inundated and flow of traffic hampered in 130 stretches of roads.

These floods alarmed the then Administration and the present Govt to appoint committees and to take remedial measures to curb flooding in Delhi.



DRAINS OF DELHI



PATH OF YAMUNA

6.6 Reasons of flooding in Delhi

- 6.6.1 Heavy Rainfall / Flash floods** The territory of Delhi has been experiencing floods mainly from Sahibi Nadi (passing through Najafgarh Drain) and Yamuna River passing through Delhi. The local drainage system at times found to be inadequate to meet the requirement, when there is heavy rain fall or during flash floods. Delhi normally remained flooded to the extent of 70000 hac (50% of its geographical area of 148300 hac from 1953 to 1984).
- 6.6.2 Urbanisation** Due to fast urbanisation during last four decades resulting in increase of paved area and decrease in the agricultural land which used to act as a percolation zone. Due to the growth of Delhi, the catchment area of the Najafgarh drain has been built up and paved resulting increase in water-flow during rainy season. The cross-sectional area of the drain has become inadequate resulting in frequent flooding of areas along the drains. Same is the situation with River Yamuna and its flood plain in East Delhi. Further **Unplanned urbanisation is also a key cause of flooding.**
- 6.6.3 Unauthorised colonies** There are about 1650 unauthorised colonies which have been developed by the local colonisers on the open/agriculture land without consideration to the city plans, drainage, sewerage etc. and thus subjected to flooding during heavy rain falls. Many more are coming up which would further increase drainage congestion and flooding.
- 6.6.4 Trespassing on storm water drains** The areas which were essentially created by the storm water drains(or constructed) to let their flood waters pass freely being tress-passed by JJ Clusters, Slum dwellers, small shopkeepers, motor garages, garbage dumping etc result in obstruction of water flow and thus contributed immensely to the fury of floods. Most of the Delhi drains can be seen such trespassing and garbage dumping.
- 6.6.5 Siltation of drains** Water treatment plants e.g. Bhagirathi, Haiderpur etc discharge sediments into drains, flow of sewerage, sullage and solid waste materials into storm water drains causing siltation which can't carry full discharge in heavy rain.

- 6.6.6 Siltation water bodies** Water bodies, low lying areas-water retaining plains, near or around the city which act as flood absorbers are gradually filled up and built upon due to urbanisation pressure. Earlier 800 water bodies in Delhi, now reduced to only 600 that too silted to a great extent. This results urban flooding
- 6.6.7 Chockage of water careers :** Accumulation of dust, garbage chocked gully gratings, bell mouths of roads and inlets of street drains, passing of cables, pipes across the drains reduces water way. Garbage dumping in or on drains, near bridges also reduce water way.
- 6.6.8 Poor Water and Sewerage Management** Old drainage and sewerage system has not been overhauled nor is it adequate now .All the drainage and sewer system in many parts of Delhi has collapsed resulting in flooding. This can be seen during rainy seasons every year at Chhatarsal Stadium in model town, Minto Bridge, Bhairon road Railway Bridge, ring road at ITO, IP estate. Back flow from main drains into city drains i/c sewers during high floods.
- 6.6.9 Deficiencies in the drainage system (Planning, Execution & Maintenance):-** The master plan for drainage of Delhi was prepared in 1976 and sent to Delhi Administration in 1981 considering problems and habitation at that point of time and did not consider for future urbanisation and particularly rural-urbanisation and unauthorised colonies. Every department/ civic bodies in Delhi plan construct and maintain their drainage in isolation without consideration of overall integrated drainage and sustainability resulting in flooding.
- 6.6.10** Failure of pumping installations due to inadequate capacity or the failure of electric supply.
- 6.6.11 Multiple authorities** in the city but owning responsibility by none. Less co-ordination among various Govt and civic bodies like MCD, PWD, DJB, I&FC, BSES, NDPL, NDMC, Cantt, CPWD etc. Control of Operation of barrages at ITO, Chilla and Okhla on river Yamuna are not with Delhi but with UP and Haryana which regulate only at request of I&FC dept of Delhi.

6.7 PREVENTIVE MEASURES UNDER TAKEN/PLANNED

After every flood in Delhi and experience gained, then Delhi Administration and present Delhi Govt has taken various preventive measures to curb floods in Delhi which resulted in safe living in Delhi to a great extent. These are illustrative and lot more are yet to be done.

6.7.1 Construction of flood protection structures

- Marginal Bunds on left bank of River Yamuna, Marginal bund on right bank u/s of Wazirabad was constructed. These act as barriers for flooding.
- Regulators were constructed on Najafgarh drain.
- After floods of 1978, the banks of river Yamuna has been raised, a large number of spurs, bed bars, studs and Left Forward bund have been constructed to protect the embankments in Delhi territory. Raising of right embankment from Wazirabad barrage d/s is under consideration for a discharge of 3 lac cusec.
- Regulators with mobile pumping arrangement had been made where there is frequent risk of main Drain/River flowing at higher level than max out fall level of outfalling drains like at Chilla, Jahangirpuri drain, Supplementary drain and at all the 15 outfalling drains into River Yamuna.
- Channelising, lining etc has been undertaken in Supplementary drain to cater for a design discharge of 5000 cusec in first phase from Kakrola regulator, for 10000 cusec from Rithala d/s in Second phase and with 15000 cusec d/s of GTK Road in third phase. The proposal for phase II and III are under consideration.
- With the construction of Ajmeripura Dam on Sahibi River in Rajasthan, Masani Barrage in Haryana, and remodeling of Najafgarh drain including construction of Supplementary drain has reduced the flooding in Delhi.

6.7.2 Improvement of drainage efficiency

- Desilting, cleaning of road, bell mouth, gullies, removal of debris, solid waste materials from all drains of all depts. /civic bodies is being coordinated by the E-in-Chief of MCD. The committee also to make sure that all drains are checked and cleaned before monsoon to ensure that they are not blocked or collapsed. Desilting reports and certificates are being obtained from all owning agencies before 15th June every year.
- Constructions of cunnette in NG drain for 100-150 cusec capacity flow.
- Najafgarh drain, Supplementary drain, Jahangirpuri drain, TDI, II, Shahdra out fall drains etc carry lot of silt from domestic sewers and therefore continuous desilting of these drains is being carried out by deploying about 28 machines (Dragline -18 Nos., Hydraulic excavator water master-4 Nos with trucks, dozer, barges having total desilting capacity of 250 cum /hr though out the year. More machines are being purchased. Desilting also being carried out through contract where these machines can't be deployed.
- Vasant Kunj, Mahipalpur and Dwarka area lack proper drainage system and suffered flooding. The I &FC with DDA, PWD, Airport authority, CISF, MCD, Metro rail, railways etc.is working on it to work out a comprehensive plan on sharing basis using STPs with covered drain of ultimate 1000 cusec capacity.

6.7.3. 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. There are many ways of rain harvesting as illustrated below adopted by Delhi Govt which will go a long way in reducing urban floods. Construction of Tankas is another system of rain harvesting used particularly in villages where land is normally not costly.

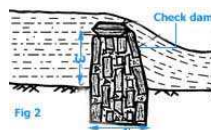
A. On-channel storage of Rain Water in storm drains:

Rain Water is being impounded in 30 km length of Najafgarh (NG) Drain from Dhansa to Kakrola Regulator (by I &FC) by closing gates at Kakrola. 6.5 km of NG Drain has also been deepened impounding 155 MG water annually and further 2.3 km is proposed to be deepened by 1.5 m. the Mungeshpur drain has been regraded in 12.5 km impounding 4 MG water.

B. Artificial Recharge Trenches:

49 nos (cost approx 1.0 lac each) in bed of Mungeshpur drain in North West Delhi in 7.3 km; 27 nos in borrow-area of Mundela Bund in 6.32 Km, 11 nos. in Khera Khurd storm water drain in 1.65 Km, 32 nos. in abandoned reach of Burari escape drain in 4.85 Km in consultation with Central Ground Water Authority (CGWA) have been provided. Similar trenches in other drains are also proposed to be provided.

C. Check Dam:



23 Check Dams had been constructed in Asola Wild Life Bird Sanctuary in hilly area of Delhi. These check dams have been proved very effective in flood protection and ground water recharge.

D. Development and deepening of village ponds:

150 ponds/johars have been developed and deepened all over Delhi which will impound 300 MG water, 175 ponds are under pipe line to be development.

E. Providing Retention basins

It is necessary to allocate certain areas to be used as retention basins for detaining excess water to prevent flooding in low areas, road, and streets. The abandoned course of Bawana Escape drain at Haranki (near river Yamuna) has been developed by I&FC depart in 58000 sq.m area impounding river Yamuna's flood water. Yamuna's flood water is also diverted in to Bhalswa Lake. The Mungeshpur drain, NG Drain and The SD Drain are also used as retention basin at their out fall.

F Creation/Revival of water bodies:



In Delhi, there are about 629 water bodies in record which are being revived and developed to take rain water. Govt of NCTD has issued direction to develop these water bodies in following manner:-

1. To survey all water bodies upto its catchment area.
2. To remove all encroachments coming in catchment area.
3. To provide drain if encroachment is not possible to remove
4. To provide STP's so that sewerage/sullage do not entered into water bodies.
5. To deepen the water bodies upto its protecting/impervious layer.
6. To provide plantation around and in catchment areas to reduce erosion.

With these directions of the Govt., the schemes are being prepared which would cost approx 500 crores and would arrest flood situation in Delhi besides increase in water wealth.

G Rain Water Harvesting Structures:

Buildings-by laws have been modified to provide rain water harvesting in building plots more than 500 Sq. m in area including Roof top rain water harvesting. Some RWS's are also voluntarily adopting this system in their colonies by good campaign of the Govt.

6.7.5 Flood-plain management :

The Yamuna Development Board, Yamuna Action plan-I, Yamuna Action plan- II and Usha Mehra committee etc are working for river Yamuna and its flood plains. A lot of JJ clusters and other structures along the banks and in the flood plains of river Yamuna have come up resulting in reduced flow. The High court of Delhi has constituted Usha Mehra committee to remove all encroachments up to 300m from water edge. This has resulted in removal of all JJ clusters and other structures reviving the original course and flood plain of river Yamuna. It will definitely help in more flow and retention of water during floods. Under Yamuna Action Plan –II – A coordinated efforts are being made by all deptt and civic bodies for total Water Cycle Management of Delhi in relation to Yamuna and its flood plains.

6.7.6 Planting sturdy trees sustaining draught as well flooding: Stress has been given by The Govt Delhi for tree plantations where-ever land is available and particularly on road sides, along drains etc. Approx 5 lac trees are being planted every year. This will result in reducing soil erosion and run-off coefficient of the area and in turn reduce the flooding.

6.7.7 I&FC dept has started preparing of Master drainage plan of Delhi in consultation with all deptt of the govt. These data shall be properly documented and shall be used in planning and construction of drainage system of Delhi.

6.7.8 Land use and development planning

- DDA has been given responsibility to prepare master plans considering drainage aspects besides others for the development of the city. The DDA, MCD and the Delhi Urban Art Commission are responsibility to strictly follow the plans while developing the area.
- Certain area has been declared as reserved forests where construction of any kind is prohibited
- The land use and its planning in river New Yamuna is being looked by the DDA and supervised by the Central Water Commission, Delhi.

6.7.9 Suggestions of past expert committees on Delhi floods and drainage

A Reddy Committee (1959): Recommended to remodel the drainage system of Delhi for an intensity of rain fall likely to occur once in two years i.e. for 42 mm/hr which gives discharge of 1.5 cusec /acre in urban area, @ 1.0 cusec/acre for city streets and 10 cusec /sq.mile for rural area. It was also suggested to review the drainage plan when future MPD is planned.

B Moti Ram Committee (1965): Recommended increased discharge capacity of Najafgarh drain to 10000 cusec

C Jain committee (1968): Suggested preparation of Master plan of drainage of Delhi, c/o supplementary drain with discharge capacity of 4000 cusec to serve up coming urbanisation as per MPD 1961

D OP Goel Committee (1993): Suggested for coordinated efforts by all. Drainage problems having inter state ramification i.e. UP, Haryana, Rajasthan and Delhi needs to be resolved through central agency i.e. CWC. Open drains are suitable but for city like Delhi where land is a precious commodity, covering of drains may be think in certain areas where drain depth is more than say 1.5 m and available space can be used for road, parking or other commercial activities.

7.0 FLOODING MANAGEMENT- SAFETY TIPS

7.1 Before flooding:

A By Government :-An Apex committee for flood –mitigation is working under the Chairmanship of the Hon’ble Chief Minister of Govt of Delhi with all ministers , MPs , some MLA and heads of all Govt /civic bodies looking after drainage, health, communication, food & supplies and dealing with basic amenities are its members with Chief Engineer (I & FC) its member-secretary. Central control rooms are set up by MCD, NDMC, Police, Transport, Health, Home Guards & Civil Defence, Food & Civil Supplies, Flood Control Deptt., Delhi Development Authority, Education Department, PWD, Govt. of Delhi, BSES, NDPL, Delhi Jal Board and all connected to control room of CWC.

Guidelines on floods and complete information of nodal persons, arrangements, list of vulnerable points are issued as “**Flood Control Orders**” every year by the Divisional Commissioner of Delhi.

Flood control Department installs 25 wireless stations, one central control room connected with other city control systems of various deptt. Arrangement of flood materials like Empty Cement Bags-58500, Stone- 5714Cum, Ballies -2250, Boats-50, Life Buoy-211, Boat – Trolley-28, Boat Engine-24, Trucks-11, Life Jackets-471, Pumps-104 with pumping capacity of 330 cusecs, silt excavator machine -28 Nos and Motorola sets to all officers had been made to curb the Delhi floods.

The bench mark for alarming flood situation in Delhi is the water level of River Yamuna at Old Railway Bridge. The Warning level is **204.0 m** and danger level is **204.83m**. Warnings are also issued when discharge at Tajewala and Masani barrages are- **FIRST** Warning at one lakh and 35000 cusecs ,**SECOND** at 3 lakh and 70000 cusecs, **THIRD** warning at 5 lakhs and one Lakh cusecs are released from these barrages. The warning level in Delhi has been attained every year except in 1987, 1991 and 2004.

B By Individual: - Flood insurance policy for house should be procured. Have a disaster plan and prepare a disaster supplies kit for your home and car. Include a first aid kit, canned food, bottled water, battery-operated radio, flashlight, protective clothing and written instructions on how to turn off electricity, gas, and water.

7.2 During flooding:

This is on site measures require highest degree of efficiency and promptness. Some of them are illustrated here.

A By Government :- Evacuation priorities and needs, Identification of Evacuation sites, Evacuations during Un-expected flooding, Shelter management plan, Evacuation support plan, Live stock protections plan, Search and rescue of people and live stock, Setting up of Communications system, wireless system, control rooms, Health operation and first aid. Immediate relief measures like supply of food, water, essential commodities, evacuations of flood victims; plugging of breaches, protection and emergency repairs of public transport system etc.

Pumping out water from ponds, low lying areas, (the I&FC dept is having 205 pumps with 2250 HP and capacity aprox 330 cusecs which are used during flooding in any area allotted to it in Delhi). Total DJB’s Pumps-installations are 70 Nos. with capacity of 1000cusec.

B By Individual: - Use sandbags or pillows or rugs to fill the airspace of a door during rising flooding, put the expensive things, electronic appliances, food and drinks upstairs or as high as possible, Switch off the power supply ,Move to a safe and higher ground quickly. Be cautious at night, because it's harder to see flood dangers. If told to evacuate, do so immediately. Avoid areas subject to sudden flooding like low spots or already flooded areas. Do not attempt to drive through a flooded road. The depth of the water is not obvious and the road may be washed away. Kids should never play around high water, storm drains or viaducts. Keep listening to the latest news and announcements from the police or local flood management team and obey instructions being given and cooperate and keep patience.

7.3 Flood measures after cessation of floods:

Restoration of power installation, public assets like road, railways, bridges, sewerage and water supply schemes and drains, merchandise and shopping areas, industries / factory equipments, public building, etc. Demarcation of land lines & removal of overlapping sand/Silt layer of flooded area are to be done. System of post-monsoon surveys needs to be done and corrective measures are adopted in time bound manner to avoid flooding in future. Always boil drinking water. Electrical equipment should be checked and dried before used.

7.4 Failures of Flood Management Policies

Floods may or may not occur regularly. The level, duration, extent and timing of their occurrence vary from event to event. Where flood occur after long intervals, (it may create immediate crises) memory of crises also fades away and so the preparedness of flood management also disappear.

Failure to adopt a comprehensive and effective flood management policy may be due to:-

1. Lack of adequate funds
2. Flood problems are technically complex and prediction of next occurrence is difficult.
3. Multiplicity of deptt/local authorities and Lack of coordination amongst these bodies.

8.0 Conclusions

Mindless urbanisation, encroaching upon and filling up natural drainage channels and urban lakes and water bodies to use the high-value urban land for buildings, illegal colonies and industries, increase in paved area, heavy downpours over Delhi and heavy discharges in Yamuna and Sahibi river. Delhi has suffered heavy floods in past. Planning has been thrown to the winds. The flooding has several impacts /effects on human-lives, animals, trees, plantations, eco-system of the area. If not taken seriously, it may cause a great set back to civilizations. The preventive measures like improvement of drainage efficiency, construction of flood-protection structures, increasing areas around the city to serve as retention basins, adopting rain water harvesting system, water re-charging of channels, etc are some of the preventive measures to curb urban flooding. The main responsibility in curbing the Delhi flooding rest with Irrigation and flood control department of the Delhi Govt which has taken many steps in this regard like strengthening of embankments of river Yamuna, c/o supplementary drain and its deepening and lining to increase its carrying capacity to 5000 cusecs. The carrying capacity of Najafgarh drain has also been increased from 5000 to 10000 cusecs by deepening and lining in city area. The NG drain has also been used for water retention. Check dams, recharge well, creation and revival of water bodies has also been under taken by I &FC dept. Besides this, I&FC dept is also working out a fresh Drainage plan of Delhi associating DJB, MCD, DDA, PWD etc to further take action on curbing the flooding in Delhi. The political will is also of prime importance to curb/reduce urban flooding by enacting legislations and getting it implemented faithfully. A lot of experience has been gained with recurring floods in Delhi. A proper authority under head of the state should look after the flood control measures with implementation in time bound manner as nothing is costlier than a life in the world.

Er. M C T Pareva, Chief Engineer, Irrigation and Flood Control, Govt of N C T Delhi.

Setup central control rooms by MCD and NDMC, Police, Transport, Health, Home Guards & Civil Defence, Food & Civil Supplies, Flood Control Deptt., Delhi Development Authority, Education Department, P.W.D., Govt. of Delhi, BSES, NDPL, Delhi Jal Board

The territory of Delhi has been experiencing floods mainly from Sahibi Nadi (passing through Najafgarh Drain in Delhi) and Yamuna River. Moreover, local drainage system has also been, at times, found to be inadequate to meet the requirement, when there is heavy rain fall or during floods.

The functions of Central Flood Control Room:

to receive flood warnings and to submit Flood situation reports to the Chief Minister, Chief Secretary, Divisional Commissioner and Secretary (I&F) every evening, to issue necessary Flood warnings and directions for evacuation, to arrange necessary food articles and relief supplies, to maintain Liaison with Upper Yamuna Division of C.W.C., R.K. Puram, New Delhi and Army/Air Force, when required. To maintain a fleet of vehicles needed for mobility of staff and the relief measures

(Relief Camp) shall assist the Sector Officer in the process of evacuation and rehabilitating the affected persons in the relief camp. He shall maintain record of the persons/ families in the camp and make arrangements for providing items of daily use and to ensure adequate health, sanitation, water supply and street light facilities.

Total DJB's Pumps-installations are 70 Nos. with capacity of 1000cusec.

The floods of the years of 1924, 1947, 1955, 1956, 1967, 1971, 1975, 1976, 1978 are the main examples of the flooding in River Yamuna when the normal lives of the residents of Delhi were either disturbed or threatened, badly.

Years: 1967, 1971, 1975, 1976, 1978, 1988, 1995 and 1998

Flood of 1978 Out of the above the flood of 1978 has been the highest recorded in the available history of River Yamuna which was recorded as 207.49 m (680.75 ft.) on 5/6 September, 1978 at Delhi Old Railway bridge, with a discharge of 7175 cumecs (2,53,350 cusecs). The right marginal bund between palla village and Bawana Escape out-fall also breached which caused a very large area of Alipur block and urban colonies like Adarsh Nagar, Model town, Mukerji Nagar submerged under deep water. Apart from the damages estimated at nearly Rs. 10 crores, eighteen lives were lost and thousands of people were rendered home less. On the left bank also Shahdara marginal bund reached the point of distress but could be saved by raising its heights in certain reaches with earth filled bags.